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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SPACECRAFT PROGRAM

QUARTERLY STATUS REPORT (U)

NO. 10
FOR PERIOD ENDING
DECEMBER 31, 1964

MANNED SPACECRAFT CENTER

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NASA

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CLASSIFICATION CHANGE

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CONTENTS

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TABLES

FIGURES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SPACECRAFT PROGRAM

QUARTERLY STATUS REPORT NO. 10 (U)

for

PERIOD ENDING DECEMBER 31, 1964

By Manned Spacecraft Center

SUMMARY

The major accomplishments of the Apollo Spacecraft Program during this reporting period were the following:

Boilerplate 23 (BP-23) was successfully launched from White Sands Missile Range (WSMR) at 8:00 a.m. m.s.t. on December 8, 1964. All major test objectives were achieved, and satisfactory data were obtained to verify the abort capabilities in a maximum dynamic pressure region. A Little Joe II was utilized as the launch vehicle.

During the flight, the launch escape subsystem (LES) satisfactorily separated the command module (CM) from the service module (SM) and then propelled the CM from the launch vehicle. All three LES motors and the canard deployment system functioned satisfactorily. The canards caused vehicle turnaround as planned, and the earth landing subsystem, using dual drogue parachutes for the first time, aided in damping the CM oscillations. All spacecraft and launch vehicle subsystems performed satisfactorily.

Spacecraft 001 (SC 001) was checked out at North American Aviation (NAA), Downey, and was shipped to WSMR on December 19, 1964. The spacecraft (SM only) was installed in its test stand at the Propulsion System Development Facility (PSDF). Hot propulsion testing of the service propulsion subsystem (SPS) is scheduled for February 1965.

The Lunar Excursion Module (LEM) ground test program logic was re-evaluated and the program was streamlined by incorporating parallel testing and eliminating many series testing requirements. Consequently, the equivalent of four LEM test articles was deleted from the program, and numerous changes were made in the assignments of the remaining test articles.

The communications, flight instrumentation, reaction control, and service propulsion subsystem components were installed in BP-14. The vehicle was connected to the Acceptance Checkout Equipment Ground Station NAA no. 1, and a satisfactory combined systems checkout was performed.

A dummy spacecraft-launch vehicle adapter (SLA) was fabricated at NAA, Tulsa, and was shipped by Army CH-47A helicopter to Kennedy Space Center (KSC) in December to confirm the helicopter method of transporting adapters. The dummy adapter will be used as a facilities verification vehicle at Merritt Island Launch Area (MILA). The first flight weight adapter was also manufactured at NAA, Tulsa, and will be shipped to Marshall Space Flight Center (MSFC) in January 1965, for use with BP-27 in space vehicle dynamic testing. The LES and CSM for BP-27 were also fabricated and shipped; the LES was sent directly to MSFC, and the CSM were sent to Manned Spacecraft Center (MSC) for structural testing before final shipment to MSFC.

The first LEM ascent development engine and the HA-3 heavyweight ascent propulsion development rig were delivered to the PSDF-WSMR. The first firings are scheduled for early 1965.

The Bell Altitude Simulation Facility completed acceptance testing, and several ascent engine development tests were run in this new facility.

The CSM stabilization and control, electrical, and environmental control subsystems trainers were delivered to MSC. The trainers were installed and are now operational.

The launch escape subsystems for BP-16 and BP-26 and associated ground support equipment were shipped to KSC.

The environmental control subsystems for SC 006 and 009 were delivered to NAA, and the SM structural subsystems for both spacecraft were completed. In addition, structural fabrication and assembly of the SC 006 CM were completed.

Fabrication of LEM test article 2 is nearly complete, and shipment to MSFC is scheduled for February 1965.

Three NAA acceptance checkout equipment-spacecraft (ACE-SC) ground stations were delivered; ACE-SC Ground Station NAA no. 1 became operational last quarter, Ground Station NAA no. 2 became operational on December 1, 1964, and Ground Station NAA no. 3, delivered in December 1964, is scheduled for acceptance testing in January 1965.

NAA was directed to activate Hypergolic Building 1 at MILA to support checkout of SC 009.

The MSC/WSMR-PSDF common use laboratory was completed.

All manufacturing and systems installation were virtually completed for BP-22. Apollo Test Operations factory checkout will start early next quarter. Little Joe II (12-51-3), the launch vehicle for BP-22, entered manufacturing acceptance evaluation at General Dynamics/Convair on December 16, 1964.

The LEM landing radar and LEM-CSM rendezvous radar breadboards were completed. The landing radar breadboard is undergoing bench test evaluation. Flight tests are scheduled to start in March 1965.

Westinghouse was awarded the contract for the LEM TV camera development. In the CSM camera development, all engineering model TV cameras were completed, and development model production was initiated.

Qualification tests of the 25-ampere-hour Eagle Picher entry battery scheduled for use on SC 006 were satisfactorily completed in October 1964.

The qualification burst tests program of the CSM O_2 and H_2 cryogenic pressure vessels was completed.

The first series of the service propulsion subsystem F-2 engine tests was completed. All major test objectives were achieved.

The design of the adapter separation system was completed, and all manufacturing drawings were released.

All experimental model VHF transmitter-receiver units for the LEM communications subsystem have passed acceptance testing and were delivered to RCA.

The MSC Guidance and Control Division lunar landing simulation was satisfactorily completed except for a preliminary study of the effects of radar velocity errors on pilot touchdown performance. The data obtained from the simulation are being analyzed.

PROGRAM DESCRIPTION

The Apollo Space Vehicle, consisting of the spacecraft and launch vehicle, is depicted in figure 1. The spacecraft is the responsibility of the Manned Spacecraft Center (MSC), Houston, Texas, while the launch vehicle is being developed by the George C. Marshall Space Flight Center (MSFC). The Apollo spacecraft configuration is shown in figure 2.

The Apollo spacecraft is composed of three separable modules: (1) the Command Module (CM) which houses the crew from the earth to the vicinity of the moon and during their return to the earth, (2) the Service Module (SM) which contains the propulsion subsystem as well as other subsystems, and (3) the Lunar Excursion Module (LEM) which separates from the Command and Service Modules (CSM) when in lunar orbit, descends to the lunar surface for manned exploration, and returns the crew to the orbiting CSM.

The basic launch vehicle for lunar missions is the Saturn V, which consists of three stages: The S-IC, S-II, and S-IVB. The S-IC utilizes LOX-RP-1 propellants for five F-1 engines while the S-II stage uses LOX-LH_2 propellants for five J-2 engines. LOX-LH_2 propellants are used for the one J-2 engine in the S-IVB stage.

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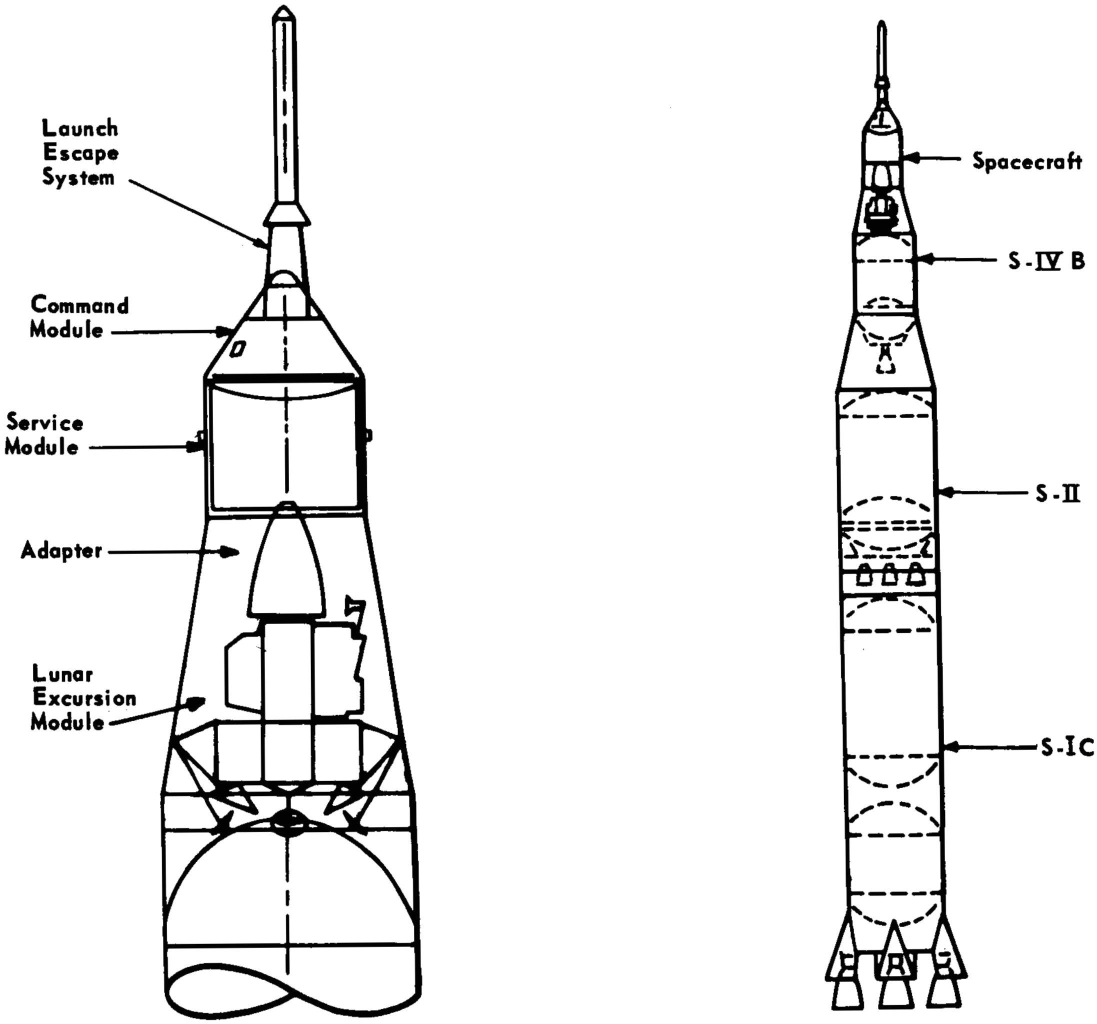

Figure 1.- Apollo space vehicle configuration.

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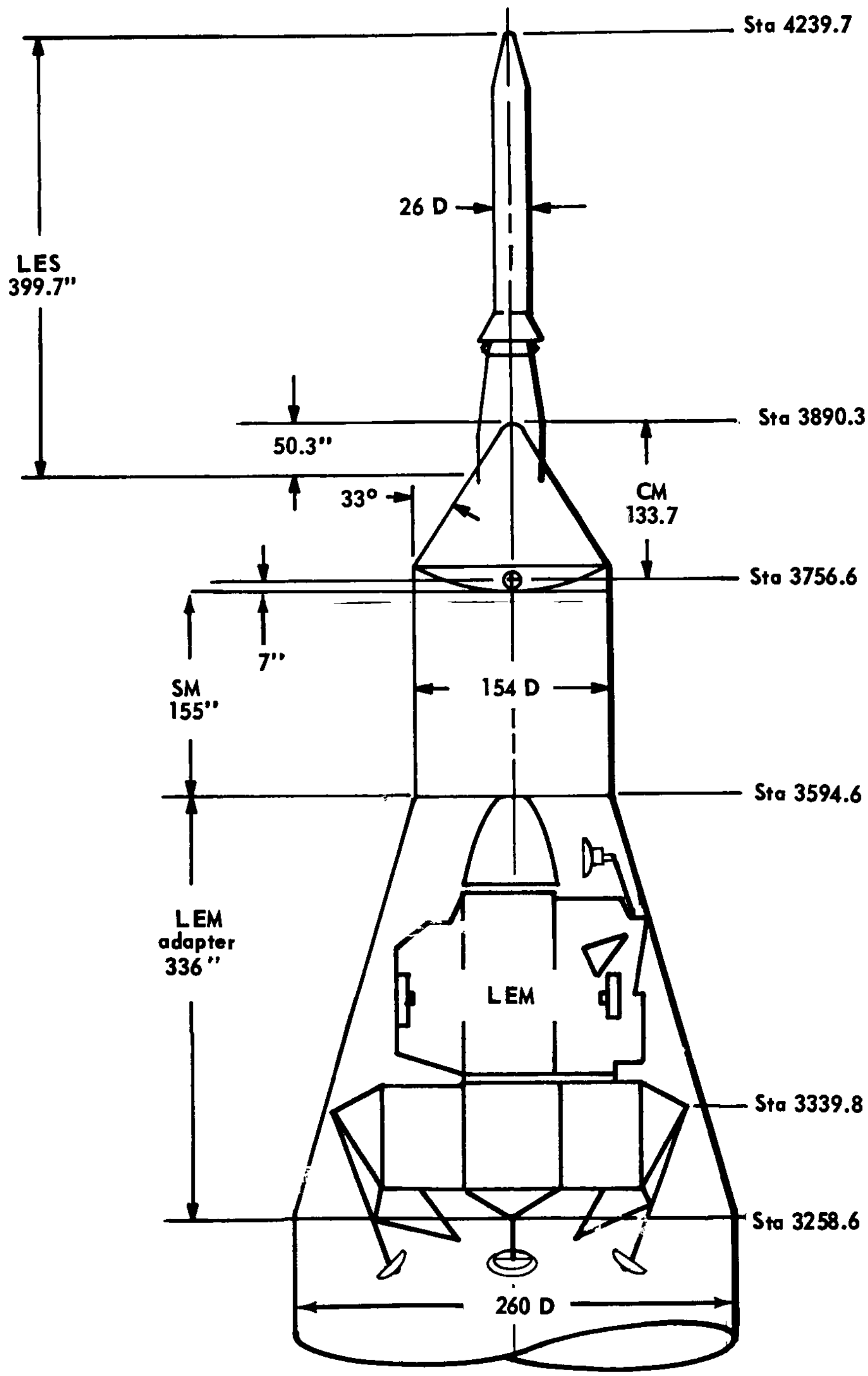

Figure 2.- Apollo spacecraft configuration.

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SPACECRAFT SUBSYSTEM DEVELOPMENT

COMMAND AND SERVICE MODULES

Guidance and Navigation Subsystem

The Block I and II CSM Technical Specification and Master End Item Specifications were reviewed, and NAA and MSC agreed on the required changes in the guidance and navigation (G&N) portions. Also, the Block I and II CSM – G&N Performance and Interface Specifications were prepared. Review is scheduled for February 1965.

Stabilization and Control Subsystem

Honeywell delivered the stabilization and control subsystem (SCS) for BP-14 to North American Aviation (NAA). The subsystem was installed, and all installation procedures were successfully completed.

Phase I of the qualification test on the SCS for spacecraft 009 (SC 009) was completed. Phase II is scheduled for next quarter.

Honeywell is now subject to the Block II SCS procurement specifications and statement of work prepared by NAA.

Structural Subsystem

Vibration tests to determine the shell and panel modes, natural frequencies, and structural damping of BP-27 were completed. The second phase of tests, designed to produce axial and lateral bending mode data, is scheduled for completion on February 10, 1965.

The BP-23 flight, the first flight to use the command module (CM) boost protective cover (BPC) satisfied all structural test objectives except the structural performance of the BPC during an abort in the maximum dynamic pressure region. Two radar antenna covers on the BPC separated during the boost phase, and one-eighth of the BPC separated just after abort. The rest of the cover remained intact until the turnaround maneuver.

The structural test to determine the CM pressure loads in the maximum dynamic pressure region was satisfied. Direct LES plume impingement data were not obtained; however, the jet-effects data were 10 to 15 percent lower than the wind tunnel data for a comparable flight.

In addition, the tests satisfactorily demonstrated the structural performance of the launch escape subsystem (LES) with the canard subsystem.

Significant loads on the SM during the boost phase of flight were caused by a structural response to a 3.5 cps oscillation of the aerodynamic control surfaces. Loads at the CSM interface were approximately 90 percent of the allowable limit. However, loads during the pitch-up maneuver before abort were only about 20 percent of the allowable limit. During the maximum angle of attack following abort, the loads at the LES/CM interface reached about 95 percent of the allowable limit. Dynamic pressure at abort was higher than the nominal values anticipated for Saturn missions.

BP-28 is being used to determine the structural capability of the CM during water impact. The lower half of the CM is spacecraft structure and the remainder is boilerplate. The first drop of BP-28 was made on October 30, 1964. Two and one-half minutes after impact, the CM sank. Consequently, the design of the CM aft heat shield was reevaluated. The reevaluation indicated that a new aft heat shield with a denser honeycomb core and thicker faceplates is required.

The SM structure for SC 006 was completed on November 6, and the SM structure for SC 009 was completed on December 28.

Mechanical Subsystem

The first operational test of the LES canard was satisfactorily completed during the max-q abort flight of BP-23. The canards were deployed 11 seconds after abort and remained deployed until after tower jettison. All components functioned as planned.

The docking system development and qualification tests will be conducted at MSC in a joint NAA-MSC test program. The test equipment will consist of a servo-drive system, a hybrid computer, and MSC's vacuum chamber B. On December 22, Northrop Space Labs and General Dynamics/Astronautics completed competitive preliminary designs of the servo-drive system.

Thermal Protection Subsystem

The data from the Scout R-4 flight test were analyzed and correlated with design techniques used in the heat shield. For pressures less than 1 atmosphere behind the shock, the test data verified the ablator design technique.

SC 006, the first CM to have a complete ablative heat shield, is about 90 percent complete. AVCO is scheduled to ship it to NAA on April 11, 1965. SC 006 is being used to verify manufacturing techniques for subsequent CM's. Later, it will be utilized by NAA as a house spacecraft.

SC 009, the first reentry CM, is being manufactured at AVCO. BP-28 drop tests have resulted in the return of the SC 009 aft heat shield structure to NAA for stiffening. Present schedules indicate that the CM heat shield will be shipped from AVCO in June 1965.

Earth Landing Subsystem

BP-23 demonstrated satisfactory operation and performance of the earth landing subsystem (ELS) using reefed dual drogues.

Ten aircraft drop tests were conducted during the quarter.

BP-19 was dropped before the BP-23 flight to verify system performance with the apex forward during high-q flight conditions.

Seven cylindrical weight "bomb" tests have indicated that the present main parachute design is inadequate. Modifications are being made to increase parachute strength to the required value. Two parachute test vehicle drop tests, the first flight tests to utilize mortar deployed steel cable risers on the drogue and pilot parachutes, were conducted to develop and structurally prove an actively reefed version of the drogue parachute.

The baroswitch, a component of the ELS sequencer, has been redesigned by replacing the gold plated contacts with silver to eliminate contact seizure during high current and low ambient pressures.

ORDCO is experiencing difficulty in fabricating reefing line cutters to meet the required environmental and time delay specifications. The inert material introduced into the 6 second delay powder train to increase burning time to 8 seconds has lowered the reliability of the cutter. Corrective action is being taken. All other hardware development for the ELS is progressing satisfactorily.

Crew Provisions

The food procurement specification was completed, and the procurement cycle was initiated. The CM personal hygiene items, tooth brush, dentrifice, and cleansing cloths, can best be provided by incorporating them in the food overwrap material. Thus, the items have been converted to government furnished equipment (GFE) and will be procured with the food.

The personal communications and bioinstrumentation electronics were converted to 16.8 volts to be compatible with the portable life support system (PLSS) and the spacecraft power sources. Resistors will be used in the CM, which has a 28-volt nominal power source, to drop the voltage.

In response to a request for proposal (RFP) for the bioinstrumentation system, ten proposals were received. Technical evaluation and preliminary negotiations with the two most promising contractors have been completed.

A material selection and toxicological control program was instituted to screen candidate materials by simplified methods with toxic control based on limited vacuum conditioning of the vehicle. Should a toxic condition be identified, only that laboratory testing necessary to isolate the offending material will be performed.

A program review for qualification testing of the unitized couch design for SC 012 has been completed. A revised manufacturing schedule indicates articles can be made available for the BP-28, SC 007, and 002A drop tests and all other major ground tests.

A revised Phase II manned centrifuge program has been submitted to MSC. Gondola insert for the program, including unitized couch, will start dynamic checkout on the Flight Acceleration Facility (FAF) during October 1965. Design verification tests for astronaut use are tentatively scheduled for January and February 1966.

Data on the acceptability of the couch attenuation system for limiting crew loads was very limited during the initial BP-28 drop because of deflections in the aft bulkhead and movement of the couch. The instrumentation functioned properly; therefore, subsequent drops should provide better data.

A zero-g test of the waste management fecal canister was completely successful. The device was later verified in flight.

Prototype GFE hardware was forwarded to the contractor to support the critical design review. The hardware also improved the interface control significantly.

Environmental Control Subsystem

AiResearch delivered the environmental control subsystem (ECS) for SC 006 (system 3) to NAA during the week of December 14. The ECS for SC 009 (system 4) will be delivered to NAA during the second week of January. System 5, for SC 008, was approximately 30 percent completed at the end of the quarter.

Component sequential environment testing (Group I) for Block 1 was completed satisfactorily on 17 components; four others are in process. Fifty-eight tests are required under the Group I qualification program.

The combined environment (Group III) test program progressed to the pre-test phase in two of the 14 packages. This phase of the test program consists of detailed test procedure preparation, with submittal to and approval by NAA, design and fabrication of the test fixture, and completion of the test setups. Combined temperature-vibration and temperature-acceleration tests will be performed on the 14 packages. When completed, the packages will be assembled for system level mission life cycle tests of 500 hours. AiResearch is manufacturing and assembling the qualification test hardware for Groups I and III.

The electronic equipment coldplates allocated for SC 008 were redesignated for use in the ECS breadboard test program. The ECS hardware and coldplate assembly have undergone fit-checks in the ECS breadboard test vehicle. The test vehicle is being painted. All systems will be reinstalled by February 15, 1965. The test vehicle will then be delivered to and installed in the altitude chamber at the NAA Engineering Development Laboratory.

The first large-scale development tests of the ECS radiator design for Block II were conducted at Ling-Temco-Vought. This program was initiated and monitored by MSC Crew Systems Division. Data reduction is in progress. Radiator performance programs were encountered under severe transients and at off-design conditions because of erratic performance of the test support equipment. Preliminary results indicated that the radiator concept was very sensitive to "edge effects" and required some thermal isolation from the adjacent SM skin. The best available analysis indicated a severe constraint on the Block I mission duration; however, radiator improvement or enlargement, or careful management of heat loads may be a solution. Further analysis is in progress to better define the problem. A high-level development test on several representative coldplates yielded satisfactory results.

The test buildup for the waste management system (WMS) development test program was completed except for two flow meters. Delivery of the meters is expected by February 1, 1965. Tests should then begin.

The AiResearch-supplied ground support equipment (GSE) for SC 009 to support the water-glycol cooling loop is scheduled to be shipped to NAA in February 1965. The pressure distribution unit (PDU), however, will not support SC 009. Instead, the prototype unit will be used for the checkout. The bench maintenance equipment, because of low priority, is three months behind in supporting the site activation date at Downey for SC 009. All ECS GSE supplied by NAA will support SC 009 at KSC.

The problem of applying a conformal coating to the electronic modules in the common usage CO_2 sensor was resolved. The specification will be developed jointly by Grumman and Perkin-Elmer.

The design of the CM gas chromatograph was completed and the first prototype assembled. This unit functioned satisfactorily. All interface problems were resolved and the interface control documentation (ICD) has been prepared and submitted to NASA for approval. Specifications were prepared for the procurement of GSE for this instrument.

Electrical Power Subsystem

Entry Batteries.- Qualification tests on the 25-ampere-hour (A-h) Eagle Picher entry battery were satisfactorily completed on October 14, 1964. The battery will continue to be used for ground tests and miscellaneous purposes. It is now scheduled for use on SC 006; however, because of increased energy requirements, a 40-A-h battery is needed, and Eagle Picher will begin qualification testing on this new battery in April 1965. The new battery will be used on SC 009 and subsequent vehicles.

Inverter.- At a NASA-NAA meeting held in November at Downey, NAA proposed two qualification test plans for the inverter. Plan A will be a redesign of the transformer and a rearrangement of the components to reduce audio noise and electromagnetic interference (EMI). Qualification tests will start in October 1965 and end January 1966. Plan B will be a modification of the spacecraft structure with sound-proofing in the lower equipment bay to suppress audio noise. Qualification tests will start April 1965 and end October 1, 1965. NAA is proceeding with Plan A and a reduced qualification test for SC 009 and 011.

Sequencer.- The mission A-002 (BP-23) LES sequencer and the ELS sequencer operated properly during the flight. All time delay relays operated within acceptable time limits.

Fuel Cells.- Fuel cell design verification tests were performed in preparation for Phase A of the qualification tests. No major design changes were made, but extensive work was done in control setting evaluation, component inspection technique, quality control procedures, and acceptance test criteria and procedures.

The electrode or sinter delaminations that occurred in early tests were eliminated in later test modules by more rigid quality control procedures at the manufacturer. More extensive acceptance tests at Pratt and Whitney also greatly increased the quality of those single cells used to build the test modules. Operating temperature has been raised to increase performance, because reduced temperatures to retard dendritic growth, decreased performance. No problem with dendritic growth has been noted with the present operating temperatures. A milestone was achieved with a 400-hour load sharing test with two fuel cell modules. The test data showed good response to load changes by both modules.

A number of glycol pumps have failed recently. Corresponding to these failures is the use of an inhibited water glycol cooling fluid in the module tests. Preliminary component compatibility tests with this fluid produced a black precipitate which caused no particular problems. However, module tests using this inhibitor have resulted in pump failures. The problem is being investigated.

Phase A of the qualification tests to support Block I vehicles is scheduled to start in mid-January 1965. A number of modules did not stay within the voltage regulation during the high load transients of the qualification test load profile. Increased operating temperatures and additional work on the control settings will reduce the problem. Although humidity testing did not affect the electrical characteristics, it did affect the insulation on the exterior of the pressure dome. The condensate degraded the radiation properties of the aluminum foil laminar insulation which increased minimum self-sustaining power from 563 watts to approximately 600 watts. This minimum power level will not be a problem on Block I vehicles. Additional work will be done in this area between Phase A and Phase B of qualification tests. Reactant consumption has been about 3 percent above the maximum specified. The latest electrode improvements plus the increase in operating temperature will tend to reduce this consumption.

NAA successfully ran a series of load sharing tests in the Engineering Development Laboratory (EDL) vacuum chamber. These tests will be followed by load sharing tests with the reentry batteries and operation with the power distribution breadboard.

MSC Propulsion and Power Division received a CSM fuel cell module for evaluation. Testing will begin in the thermo-chemical vacuum chamber in March.

Cryogenic Storage.- The successful testing of the fourth and final Inconel O_2 pressure vessel completed the qualification burst test program of the O_2 and H_2 pressure vessels.

Engineering model tanks EM-1 and EM-3 (hydrogen), and EM-1 and EM-2 (oxygen) have been manufactured and have been undergoing extensive dynamic and thermal tests. Both the oxygen and hydrogen tanks have successfully passed all vibration tests and met the specified minimum flow rates. However, the hydrogen tank did not meet the 30-hour standby time from ambient to minimum operating pressure or the 2-hour time from minimum operating pressure to relief valve opening. Work now being done to improve standby time appears promising. The oxygen tank met the 30-hour standby but failed the 2-hour requirement by a slight margin. Although this item is not critical, the operational aspects are being investigated.

Problems were encountered during vacuum acquisition because of the outgassing of materials in the coil cover and the moisture content of the insulation. The coil cover material was changed, and insulation handling procedures were improved. However, vacuum acquisition procedures have been revised to a 30-day schedule from a previous 7-day schedule. The change affected manufacturing schedules, but flight support of vehicles was maintained by rearranging hardware deliveries.

The fan heater motor problems reported during the last quarter appear to be resolved. Phase A qualification tests are scheduled to start next quarter.

Service Propulsion Subsystem

The first series of F-2 tests was completed on December 9, 1964. All system parameters were within specified limits except the mixture ratio. All series I test objectives were satisfied, and preliminary data indicate no major problems. The fixture was then shut down for updating. The second series of tests, 8 test series of gimballing checkouts, is scheduled to start on January 27, 1965.

Engine Development.- The Aerojet freeze date on the engine qualification design was December 20, 1964, but the injector final pattern design was delayed until January 18, 1965. Low amplitude popping problems were encountered with the 5-4-2 baffled injector, but they have not caused any hardware damage. The bipropellant valve hydraulic actuated design may be changed to a pneumatically operated design.

Phase II Altitude Testing.- The first altitude tests were conducted on December 14; the second, on December 22. Because of test scheduling difficulties at the Arnold Engineering Development Center (AEDC), all test runs were not completed. An accidental engine firing, with the cell at atmospheric pressure, resulted in a crushed nozzle extension. The engine will be removed from the cell, and the chamber and extension will be replaced before tests continue. Preliminary investigation of the failure indicates that an actuation of the bipropellant valve by either facility N_2 or excessive back pressure caused by an erroneous setting of the dump line check valve caused the accident. The Phase II tests are scheduled for completion on April 10, 1965.

The propellant gaging system design verification tests began during this reporting period. Accuracy tests of the oxidizer probes are in progress. Spot checks of the data indicate the accuracy is well within the specified limits. Accuracy tests of both the oxidizer and fuel point sensor system have not indicated any problems.

Reaction Control Subsystem

Both NAA and Bell have been advised that they must agree to a specific design of the positive expulsion tankage so that other preparations can be made. Definition of the GSE for the reaction control system (RCS) awaits resolution of this problem. Also, changes in procedural activity must be formalized. These activities must be accomplished before delivery of SC 009 to the Eastern Test Range. Little is left to be desired in the performance of the present design. The expulsion efficiency is slightly below the specification value, and the cycle life is approximately 20 instead of 50 cycles. However, these deviations will only produce insignificant reductions in spacecraft capability or reliability.

Eight components have completed qualification testing. Two of the components were qualified to the old specification on fixed price contracts. New specifications, based upon breadboard experience, are being written; and new qualification programs are being initiated.

The RCS engine programs have been attempting to establish production capability for delivery into design verification and qualification testing. Arrangements are being made to supply hardware to the Cape for verification of the procedures required to checkout, service, and launch the RCS.

Launch Escape Subsystem

Apollo mission A-002 (BP-23) successfully demonstrated the mission abort capabilities at a high dynamic pressure. All three LES motors performed satisfactorily.

Launch Escape Motor.- The Lockheed Propulsion Company qualification test report for the launch escape motor, dated December 10, 1964, was delivered to NAA during December 1964. No major performance deviations were noted.

Pitch Control Motor.- The Lockheed Propulsion Company qualification test report for the pitch control motor, dated December 8, 1964, was delivered to NAA during December 1964. The report documents several deviations of performance from the specifications. The most significant was that the average motor total impulse was 3 percent higher than expected. This high performance places the average value at the upper limit as specified. Investigations by NAA and NASA established that the performance was acceptable, and the specification was changed accordingly.

Tower Jettison Motor.- The Thiokol test cell damaged during the test of the third tower jettison qualification motor was repaired. AQ-III-4, the first motor to be tested in the cell since the malfunction, was satisfactorily tested on November 10, 1964. A total of five tower jettison qualification test motors were statically tested during the reporting period. All of the tests were satisfactory. The qualification test program is estimated to be complete on March 2, 1965.

Pyrotechnic Subsystem

The canard deployment system and its components completed minimum airworthiness tests and demonstrated satisfactory performance in Mission A-002.

The Space Ordnance Systems design of the Apollo standard initiator (ASI) completed development in December. Qualification testing is scheduled from January 20 to February 12, 1965. The HiShear design continued to experience internal pressure problems. Qualification of this design is not expected before April 1965.

Details of the "Traceability and Data Collection System" for the ASI were completed and the report form established. The system objectives are the rapid location of any initiator by serial number and the collection of firing data on every initiator. The system will provide a valuable engineering and reliability tool for assessing the capabilities of the ASI and for determining areas of improvement. Data on all Apollo pyrotechnic devices will be included in the system automatically, since all devices require the firing of an ASI. Data collection will begin with the first production lot of qualified ASI.

Continued problems in the interaction of the two modes of the dual mode bolt resulted in rescheduling the qualification tests from April 12 to July 6, 1965. BP-22 was configured for the dual mode bolt, but provision was made to revert to the single mode bolt.

After 152 consecutive successful firings, the single mode bolt failed because of an inadequate design margin and a restriction of the hydraulic medium. A modification was made to improve the margin and to provide the capability to upload the charge. Tests to prove the fix and to establish the new design margin will start in January 1965. Flight hardware to support BP's 16, 26, and 22 was ordered.

Arrangements were completed with the U.S. Army Ammunition Procurement and Supply Agency to furnish virgin RDX for Apollo. The first shipments were made on December 21, 1964. This material will be used in the spacecraft wherever high explosives are required.

Cartridge charge sizing tests for the Block I forward heat shield jettison system were completed. Cartridges were procured and verified. Tests demonstrated that one of the two thruster systems can jettison the heat shield with a minimum velocity of 26 fps.

Additional development tests of the tension tie cutters of the CSM separation system indicated that moisture between the cutting charge and tension tie had a deleterious effect. However, by filling the void with micro-balloons, the cutting capability of the charge was improved.

Firings of the CSM umbilical cutter (a linear shaped charge device) adversely affected the heat shield and high shock loadings. A guillotine driven by a mild detonating fuse gave improved performance. Opposing, redundant guillotines, each with redundant charges, are the latest design concept. This device is now in an accelerated development program.

The Eastern Test Range has withdrawn its requirements for dispersal of SM propellants; therefore, the development of the dispersal system was cancelled.

The design of the spacecraft-launch-vehicle adapter separation system was completed and all manufacturing drawings were released. Specifications for procurement of explosive components were prepared. This system required a redesign because of changed requirements for the deployed position of the panels. Development and qualification of the separation system to support SC 009 will be difficult because of the system complexity and the difficulty of adequate ground testing; however, current schedules will support SC 011.

Development and minimum airworthiness testing of the dual drogue disconnect and parachute mortar cartridges was completed. Several reefing line cutters failed to function although they had completed lot acceptance tests; failure analysis is being conducted.

Representatives from MSC, NAA, and GAEC are considering standardization of tests, test methods, procedures, and instrumentation. As a result, a specific digital ohm meter will be used for measurements of the ASI at the vendor, prime contractors, and launch sites. Action was taken to provide these instruments as GFE.

Current ASI qualification schedules will support SC 011 and 012.

A booklet describing the ASI and certain cartridges containing the ASI as an integral component was published. Specifications, specification control drawings, and information on the traceability and data collection system were included. This document will be distributed to all NASA Centers and other interested organizations to encourage standardization.

Communications Subsystem

Pre-Modulation Processor.- The acceptance test procedure was completed and approved on the model E-5 pre-modulation processor (PMP) in November. It was shipped to NAA in December. This completed the E-model PMP procurement.

HF Transceiver Orbital Capabilities.- Collins Radio Company (CRC) was directed to provide an HF earth-orbital capability. This will be provided by including a dc-dc converter in the dummy module of the HF transceiver. The change will be implemented first on the HF transceiver for SC 006.

VHF Beacon.- CRC built a prototype D-model that uses different RF power output transistors than the E-models. The power output was increased to about $4\frac{1}{2}$ watts. The unit was qualification tested in all areas except humidity. The electro-magnetic interference (EMI) was slightly out of specification, but all other test results were acceptable. A D-model design was approved by NAA.

Flashing Light (recovery).- The Gemini flashing light was authorized by NASA for use on Block I.

Up-Data Link (UDL).- The model E-2 UDL completed design verification tests and was refurbished and delivered to MSC for the S-band compatibility tests.

The D-revision of the UDL procurement specification MC 470-0014 and the J-revision of the specification control drawings were released. These revisions detailed the central timing equipment updating requirements and parameters.

The model E-3 UDL satisfactorily completed humidity and salt spray tests.

Pulse Code Modulation.- The pulse code modulation (PCM) telemetry equipment was installed in BP-14 in early October. Tests were successfully conducted to verify proper operation of the PCM and to establish a valid telemetry link with the C14-021 telemetry ground station.

Test procedures and tape programs have been computed for testing the PCM on the spacecraft instrumentation test equipment (SITE). The first demonstration to qualify SITE for PCM checkout is scheduled for January.

The D-model PCM mechanical package has satisfactorily completed the new combined salt spray-oxygen-humidity tests in Wyle Labs at Huntsville.

Antenna Status Review.- The three 2-kmc high gain study contracts have been completed by Hughes, General Electric, and Dalmo-Victor. NAA has reviewed and evaluated the final reports and will present their evaluations to MSC in January.

NAA completed their study of a second high gain antenna for the CSM. They recommended that, if two are required, the second should be identical to the first.

Operational Instrumentation Subsystem

Heat Shield.- A test of the high range calorimeter design at Ames Research Laboratory indicated that the design requirements were satisfactory.

Signal Conditioning Equipment (SCE).- CRC will ship the E-1 assembly to MSC on January 5, 1965, for electronics systems tests.

The E-3 assembly has been installed in BP-14 and has completed preliminary checkout tests satisfactorily.

Central Timing Equipment (CTE).- A status presentation by General Time Corp. to MSC personnel on November 21 indicated that all major problems have solved and delivery dates are acceptable. CSM and LEM timing equipment contracts will remain at General Time Corporation.

The crystal holders manufactured by McCoy and used by General Time Corporation failed MIL-STD-202 B vibration tests. This item is undergoing a redesign, and redesigned holders will be used on SC 011 and subsequent vehicles.

Data Storage Equipment (DSE).- Because CRC and Leach have been unable to plate the magnesium castings to meet the 1 percent salt spray requirements, aluminum will be used for the basic structure of the recorder on SC 011 and subsequent vehicles. The penalty will be about 5 pounds.

Acceptance testing of the Model E-7 DSE for SC 009 on October 12 and 13, 1964, was satisfactory except for weight. The excess weight (27 oz) is due primarily to the tape motion electronics and sensor, which is unique to this unit. Model D-1 DSE for SC 006 successfully completed acceptance tests and was shipped to NAA on December 24, 1964. A tape motion sensor will be added to all D-model DSE except for the SC 006 unit.

Transducers.- The six flowmeters for BP-14 have been received and approximately 90 percent of the transducers for SC 009 have been qualified and have been shipped by NAA.

Instrumentation/Communications R and D Subsystem

MSC Instrumentation and Electronic Systems Division (IESD) has continued to deliver GFE development flight instrumentation (DFI) systems to NAA and to support prelaunch and postlaunch phases of the Apollo spacecraft missions.

Vendor deliveries of flight hardware to MSC continue to present a few problems; consequently, committed deliveries are subject to change. The most critical problem was the qualification of a frequency modulation (FM) transmitter. The EMI problems were resolved for this component and the vendor is expending maximum effort to rework transmitters to the new design.

The SC 002 breadboard and flight hardware, except for three types of hardware, were shipped to NAA on December 3, 1964. IESD is expediting the delivery and checkout of the outstanding items.

The DFI subsystem operated satisfactorily during the BP-23 flight. Requirements for BP-23A were reviewed. Hardware, other than that salvaged from BP-23, has been ordered for delivery to NAA by March 15, 1965.

The contractor furnished equipment (CFE) DFI was limited to SC 006, 008, 009, 011, 012, 014, 015, and BP-14. An IESD-NAA review of the qualification of CFE DFI components for SC 009, 011, and 014 has indicated that the program is generally acceptable and on schedule.

Television Subsystem

All E-model cameras were completed, tested, and evaluated. One unit was delivered to NAA. Another model was received at MSC, where it was tested and incorporated into the S-band system tests. Production of D-models was initiated.

Scientific Equipment

The Manned Space Flight Experiments Board (MSFEB) submitted four experiments to those already under consideration for Block I manned flights. The experiments for Block I are now as follows:

- Nine medical experiments
- Synoptic terrain photography
- Otolith function in orbital flight
- X-ray astronomy with pinhole camera
- Human cells under zero g
- Nuclear emulsion (South Atlantic anomaly)

NAA completed feasibility studies of incorporating the experiments. MSC will evaluate the NAA studies, and by January 30, 1965, will recommend to MSFEB which experiments should fly on SA 204 and SA 205.

MSC has conducted a study of tape recording systems to support the Block I experiments. Probable solution will be two Gemini biomedical recorders for CM experiments and a separate recorder for the SM experiments.

Additional coldplates will be available for Block II buildup (non-lunar landing) experiments. For lunar landing missions, approximately 30 square inches of coldplate are available for film and tape storage. Two additional coldplates (50 sq. in. each) will be available for experiments on any buildup missions.

LUNAR EXCURSION MODULE

Guidance and Navigation Subsystem

The interrelationship of the primary G&N, SCS, and abort guidance subsystem was defined for the contractors. The MIT subsystem will provide for the primary vehicle navigation, guidance, and control. The subsystem provides for vehicle rotational and attitude control through use of the inertial measurement unit with direct connections to RCS jet preamplifiers, descent engine throttle and trim controls, and ascent engine on-off controls. Proportional trim rate commands and on-off translation commands are provided from the hand controllers to the computer.

Displays of primary and abort guidance system information have been prepared to monitor the guidance system performance during critical mission phases to support abort decisions. This newly defined system has been implemented by appropriate redirection of the contractors.

The LEM ground test logic and deliverable hardware were reviewed against vehicle requirements and schedules. A revised ground test logic to support vehicle design releases was agreed to by Grumman. The program provides integration testing of the GFE guidance, navigation, and control system with the radars, SCS, and abort guidance systems. A significant reduction in the quantity of deliverable hardware resulted.

A flight test program for the landing and rendezvous radars was established, and appropriate contractural direction was given.

Stabilization and Control Subsystem

The LEM definition study to integrate the guidance and navigation (G&N) subsystems has been completed. The study resulted in a functional configuration as follows:

a. Normal vehicle stabilization and control is provided by the guidance subsystem through computer interfaces with the hand controllers and the electronics of the SCS.

b. Vehicle stabilization and control and guidance for abort (after a guidance subsystem failure) is provided by the SCS control section and abort guidance section. The interfaces were identified and implemented in the hardware design.

The configuration and capability of the abort guidance section was defined by MSC. The significant features of the definition are the fixing of the abort computer memory capacity, the incorporation of a general purpose input/output device for crew communication with the computer, and the provision for rendezvous radar interfaces in the AGS for future use.

Structural Subsystem

The LEM structure is shown in figure 3.

The LEM full-scale metal mockup (M-5) review, held at GAEC on October 7, 1964, indicated no structural problems. The ground test program is continually being improved. The LEM test article (LTA-10) configuration has been defined. It will consist of a primary load carrying structure. LTA-10 is scheduled for delivery to NAA on May 28, 1965, for LEM-SM adapter interaction load testing.

Landing Gear Subsystem

LEM landing gear component testing was conducted to determine primary and secondary strut structural and friction characteristics, foot pad crushing characteristics, and honeycomb energy absorption capability.

The initial phase of the $\frac{1}{6}$ scale model drop test program, aimed at verifying the landing dynamics parametric study, was started by both GAEC and MSC.

Because of a LEM weight increase, the landing gear must be modified to provide the required performance. Various modifications are being evaluated to upgrade landing performance.

The proposed TM-5 test vehicle will be used to demonstrate landing stability under simulated lunar gravity. This vehicle is a prototype LEM except for the ascent stage, which is a mass-inertia simulated dummy structure. GAEC was unsuccessful in devising a method of producing lunar gravity simulation for drop tests of the TM-5 vehicle; therefore, they have proposed to use a $\frac{1}{6}$ mass, full-size vehicle for

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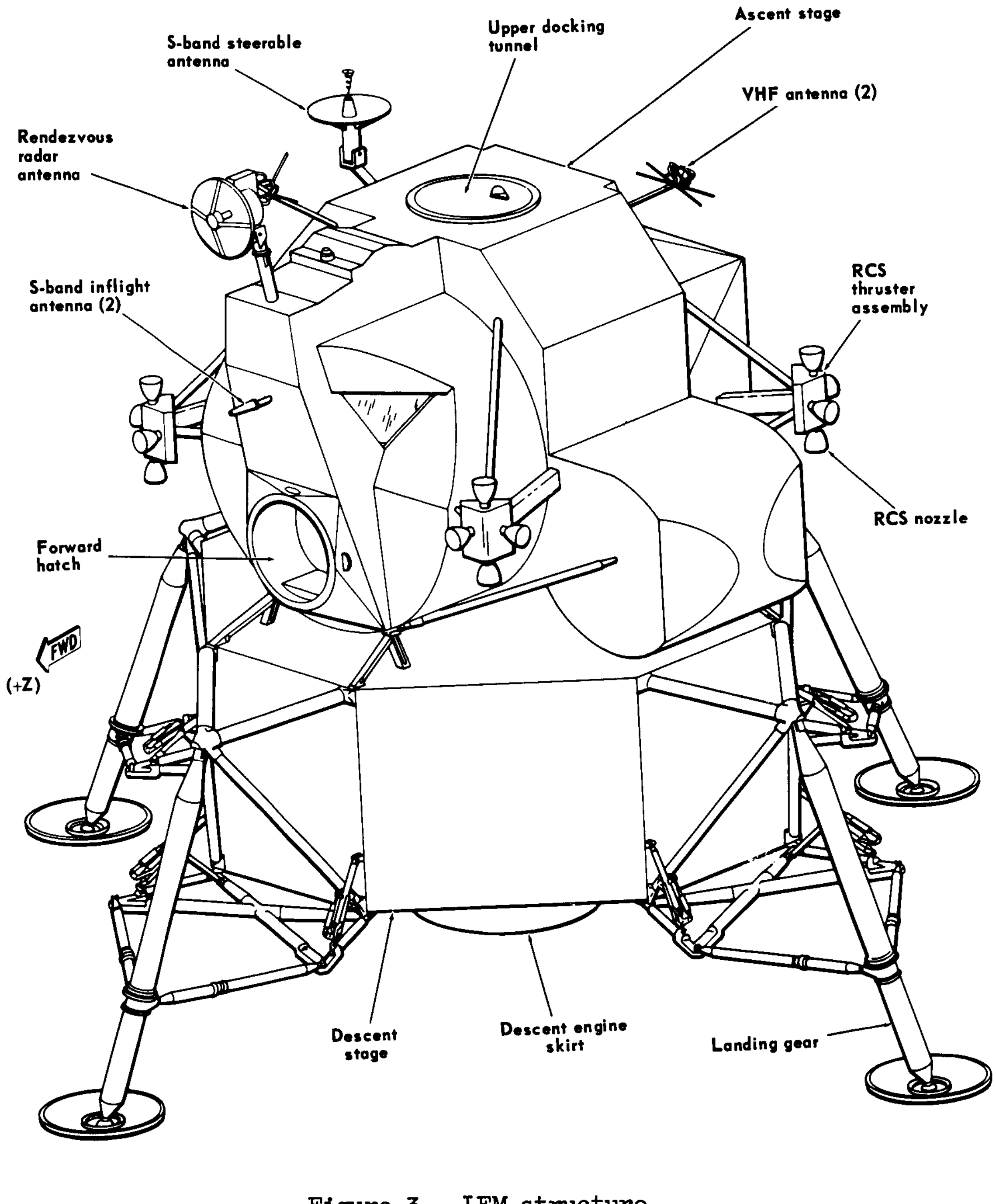

Figure 3.- LEM structure.

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1/g drop testing. This proposal, as well as the whole TM-5 phase of the landing gear program, is being reviewed.

Crew Provisions

The human impact program to define crew support/restraint requirements during lunar landing is nearly complete. The off-axis-loading drops were not completed, but preliminary results have not identified a need for a more sophisticated restraint. Zero g flights to explore this mission phase for restraint requirements are programed for January. Completion of the two test phases will determine the necessary crew restraint.

Environmental Control Subsystem

Because of changes to the ECS suit supply connector and flow control, GAEC was directed to provide the space suit umbilical hoses in the LEM, a crossover valve to allow reversal of flow into the Pressure Garment Assembly (PGA), and a bypass relief, if necessary, to prevent fan surge. In addition, Grumman and NAA were directed to assure that the length of the CM and LEM umbilicals are sufficient to permit crew transfer and LEM ECS startup with both cabins unpressurized.

The design requirements for the ECS secondary (redundant) glycol loop were clarified: The flight director altitude indicator and electric supervisory subsystem are to be included but not the rendezvous radar electronics and other components of the primary navigation and guidance that are not shared with the abort guidance. Also, Grumman was requested to determine the active cooling requirement of the S-band and the VHF communications during abort duty cycles to determine if they should be included on the secondary glycol loop. The ECS development plan was updated to agree with the revised LEM ground test program. A significant reduction in the ECS hardware requirement resulted. Three equivalent subsystem deliveries were deleted by eliminating the contractor reliability assurance tests. Also, the delaying of overstress testing until after qualification testing resulted in a saving of two subsystems. The qualification hardware can be utilized for overstress testing.

Revisions to the packaging of the atmosphere revitalization section have delayed testing this quarter.

Electrical Power Subsystem

DC Distribution System.- A dc distribution conceptual design consisting of primary, transfer, and peaking buses was recommended by GAEC on November 12, 1964. In this design no bus redundancy is provided; therefore, selected utilization equipments have been provided with redundant circuit breakers and isolating diodes. GAEC has been revising the bus switching logic to optimize the dc distribution. The latest revision was submitted to MSC in early December 1964. MSC will review changes and will make recommendations by February 1, 1965.

Auxiliary Battery.- Results of the GAEC study to resize the auxiliary battery to meet the revised abort cirteria (abort with one fuel cell assembly failure) were presented to MSC on November 12, 1964. MSC approved a 50-pound, 1650-watt-hour battery.

Battery Charger.- MSC advised GAEC of the portable life support system (PLSS) battery charging requirements on November 5, 1964. In early December 1964, Crew Systems Division advised IESD that the PLSS power requirements and battery size had doubled. The new charging requirements are as follows: The battery charger is to be designed for a constant current of 2.7 amps ±0.2 amp and to cut-off when the charging voltage reaches 22.2 volts ±0.1 volt (this includes ripple content).

Inverter.- Hamilton Standard was authorized by GAEC to proceed with fabrication of the inverter breadboard model. This was the result of a conceptual design review by GAEC and Hamilton Standard on November 2, 1964. Official purchase order for the LEM inverter was issued to Hamilton Standard by GAEC on November 13, 1964.

Voltage Drop Problem.- GAEC presented the voltage drop problem to MSC on November 12, 1964. The data indicated that a 15-pound penalty is required if the problem is solved only with wire. The penalty could be reduced to 8 pounds if a combination wire and equipment specification change approach was followed. GAEC conducted additional studies to determine impact on cost and schedules. Results of these studies have not yet been presented to MSC.

Fuel Cells.- Revised filling techniques have eliminated the short term plugging, and the long term plugging problem seems to be reduced by the addition of metal foil strips. Single cells were run longer than 400 hours. The long time failure modes were dendrites rather than plugging.

The first flight-weight fuel cell stacks were run this quarter; a 15-cell stack ran for 150 hours during November, and in December, another stack ran for 57 hours.

Nickel dendrite shorting remains a problem. In November investigations were initiated on ceria coating of the H_2 electrode, lower operating temperatures, and activation techniques. Preliminary results on single cells indicate that ceria coating will retard dendritic shorting and will probably be incorporated into the program.

A thermal redesign of the fuel cell assembly (FCA) was completed. A LEM vendor change was sent to Pratt and Whitney to approve a design change for an H_2 loop to cool some of the FCA components. This change reduced the heat losses from the FCA to 55 ± 20 Btu/hr.

The auxiliary peaking battery was sized at 50 pounds. System voltage can be maintained by adding 12.5 pounds of wiring. To maintain voltage if this battery fails, the cryogenic tank heater must be manually operated.

Cryogenic Tanks.- The conceptual design review report from AiResearch was approved with minor comments. The formal preliminary design review is scheduled for January 31, 1965.

Negotiations were started on resizing the tanks from an 87-kWh capacity to a 121-kWh capacity. The initial 121-kWh system weight was 540 pounds. GAEC reduced this to 480 pounds.

Descent Propulsion Subsystem

The selection of the descent engine subcontractor has been scheduled for mid-January of 1965. Grumman is evaluating Rocketdyne and Space Technology Laboratory (STL); however, Grumman has not submitted an official statement of selection to NASA. Each subcontractor completed the same two major decision milestones of the seven originally planned.

At present, both contractors have problems in the development of their injectors. STL has marginal performance at maximum thrust and exceptionally high performance at minimum thrust. Some rough combustion continued to linger, especially at the 40-50 percent thrust range. Rocketdyne has problems with helium distribution in the throttling phase, with buzzing and popping instability, and low performance at low throttle levels. However, both subcontractors have achieved satisfactory chamber/injector compatibility.

Engine environmental tests are scheduled to begin February 15, 1965, at AEDC, Tullahoma, Tennessee. The tests will obtain thermal data during the descent mission duty cycle at simulated altitude, determine engine operation at high and low propellant temperature extremes, and determine engine performance. An HD-4 rig, a heavyweight structure with a flight-weight heat shield, and a prototype engine will be employed in the tests.

Approximately 30 percent of the propulsion GSE required for PD-1 and HA-3 testing at the Propulsion System Development Facility (PSDF)-White Sands Missile Range (WSMR) has been delivered. Eighty percent of the GSE design concept to initiate PD-1 firings was approved. The first PD-1 firing at PSDF is scheduled for May 1965.

A GAEC supercritical helium storage special task group was formed and has started work. At present, the supercritical helium pressurization system will be considered as the prime descent pressurization system and will be interchangeable with the ambient system throughout the development phase. The initial projected weight saving is 367 pounds (separation weight). The LEM descent stage is shown in figure 4.

Ascent Propulsion Subsystem

The HA-3 heavyweight ascent propulsion development test rig and the first development engine were delivered to PSDF — WSMR. The first firings will begin in early 1965. The LEM ascent stage is shown in figure 5.

The Bell Altitude Simulation Test Facility acceptance tests were successfully completed this period. In addition, several engine development tests were run in the new facility.

A phase "C" thrust chamber was fired in the altitude chamber for 545 seconds — 100 seconds over the specification requirement. A phase "C" thrust chamber, incorporating an insulating blanket over the combustion chamber aluminum jacket, was also successfully fired for 455 seconds. The maximum aluminum jacket temperature was 475° F, and the exterior blanket temperature reached 220° F. The maximum allowable exterior temperature is 300° F.

Bell has cancelled the thrust chamber development program using low density ablative materials (50 lbs/ft^3) after tests proved the materials to be unsatisfactory.

Bell also tested the two new high performance injector designs, designated B6 and B8. These injectors, modifications of the B3L design, have a higher barrier flow mixture ratio than the B3L design. Injector B8 has a mixture ratio of 1.05; B6 has a 1.20 ratio, the highest to date. Test results of the B8 injector showed an increased C* performance of 0.8 percent. The compatibility of the injector and the ablative chamber was satisfactory. The excessive streaking and throat erosion evident after the tests indicated that mixture ratios for the

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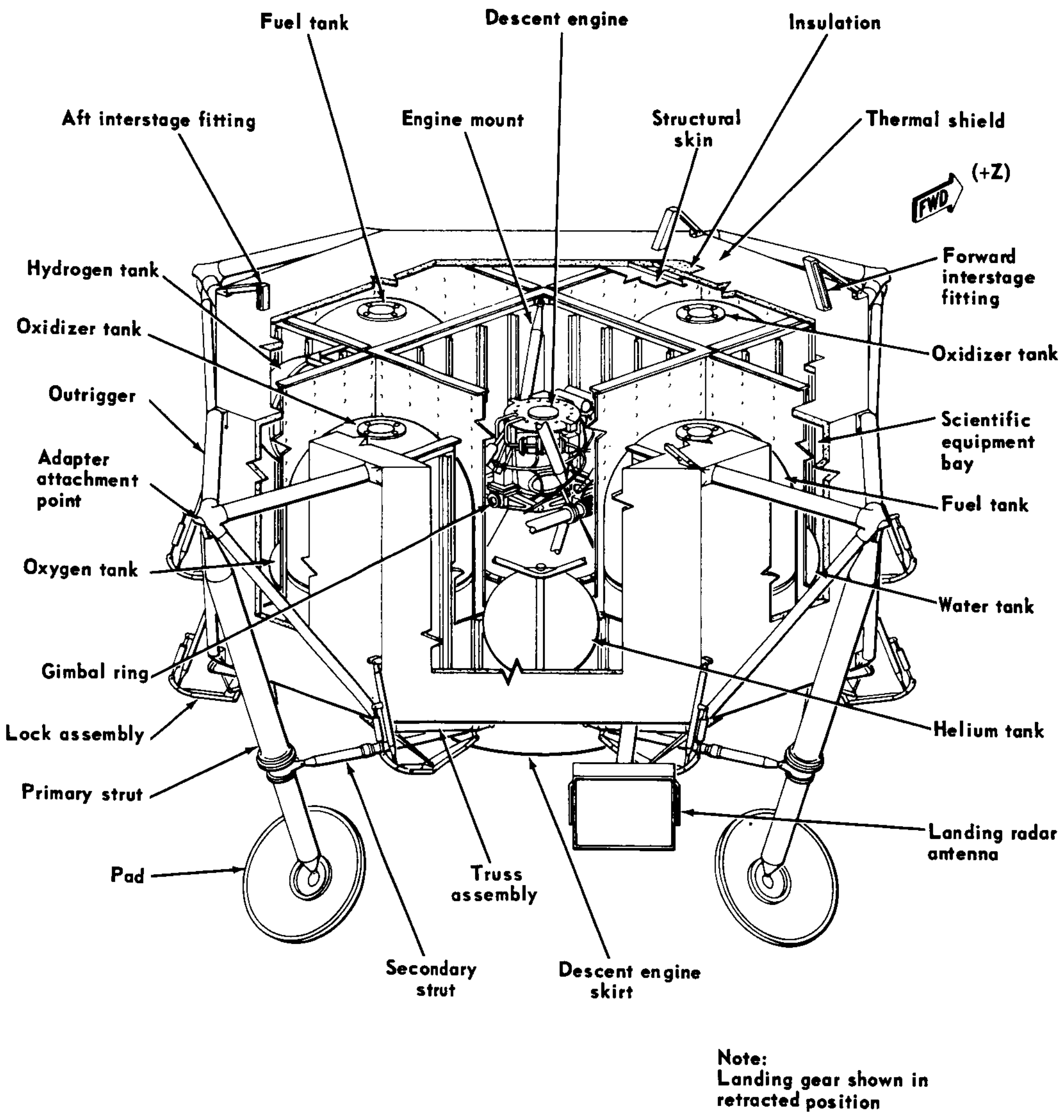

Figure 4.- LEM descent stage.

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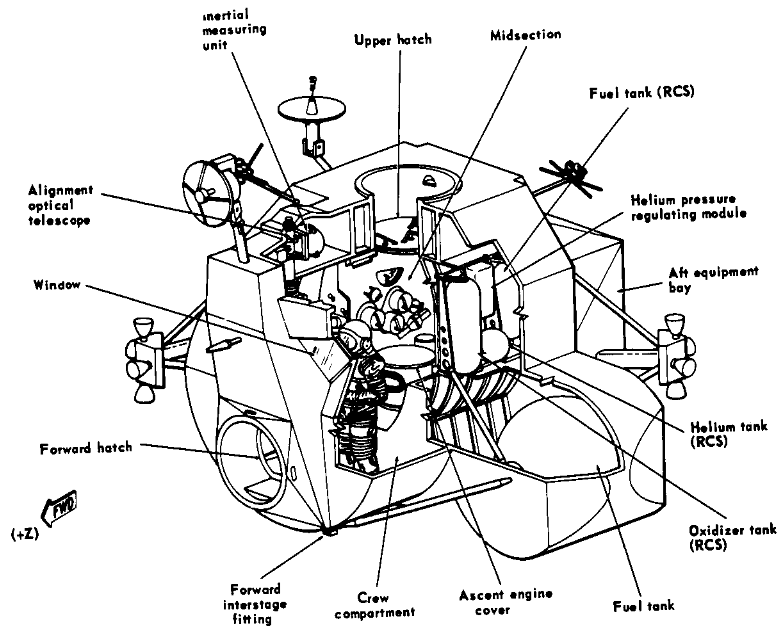

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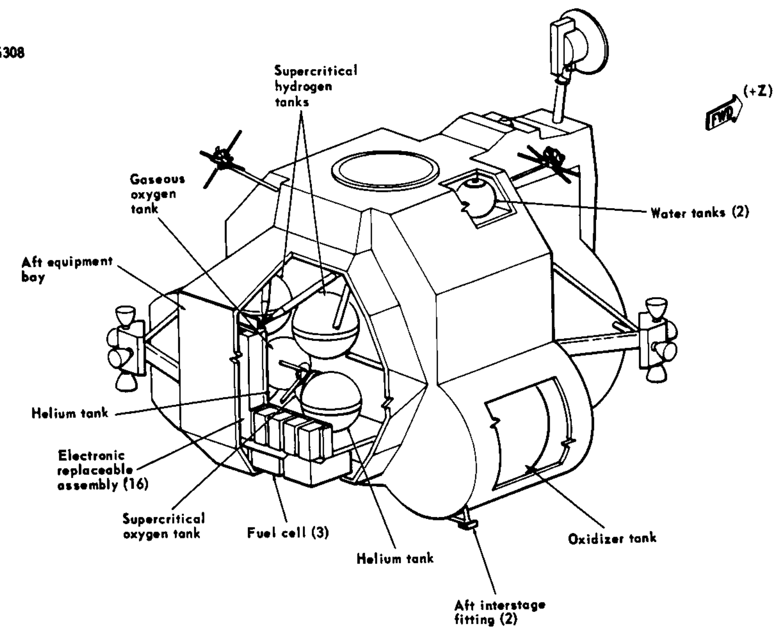

Figure 5.- LEM ascent stage.

erosion evident after tests indicated that mixture ratios for the barrier flow should not exceed 1.05. The LEM ascent stage is shown in figure 5.

Reaction Control Subsystem

The review and realinement of the RCS development and ground test program resulted in a definition of the hardware requirements and will culminate in a definition of tasks and resources.

GAEC has initiated procurement action with all but one common usage component vendors to support the ground test program. Negotiations are in progress with the vendor of the helium fill-vent coupling.

The Marquardt Corporation (TMC) has encountered an operating problem with the HR-3 testing at their Magic Mountain test facility. The problem, entrapped gas in the propellant lines, was discovered during the pulse-mode operation of the system. TMC is investigating the causes.

The development of the thrust chamber assembly has slipped because of the poor performance of the Preliminary Flight Rating Test (PFRT) engine and valve leakage. TMC corrected the valve leak; however, the redesign of the injector to improve the engine performance is still in progress.

Pyrotechnic Subsystem

The technical specification for the interstage separation device was written; the bids were evaluated; and the source was selected. The bolt, a pressure type, will operate on the same principle as the single mode bolt used as an interim tower separation device for the CSM.

The requirements for the interstage electrical umbilical guillotine and linear shaped charge cutter were established and the technical specifications were prepared.

A low priority feasibility study of an explosive disconnect for the interstage cryogenic lines was initiated as an alternate to the mechanical disconnect now scheduled for use.

The inability of available switches to handle 50 ampere currents, as planned in the original electrical system concept, forced a change to relay switches. Components are now being selected for tests. Circuitry is in the design phase. An overall specification for the pyrotechnic electrical system was drafted, and the design verification test plan for pyrotechnic firing circuitry was completed.

Requirements for deadfacing of interstage electrical circuits upon staging were established. The suitability of the CSM deadface device for LEM application is being studied.

Design feasibility tests of the landing gear uplock resulted in undesirable shock loading of the mounting structure. A piston-type release device is being designed as a substitute.

Communication Subsystem

The development program for the LEM communications has been reconfigured. In the new program GAEC will perform system integration only, and RCA will perform integration of the communication subsystem. The hardware vendors will have the responsibility for supplying hardware which they have qualified. The packaging configuration has been changed to allow packaging by individual vendors, replacing the earlier concept in which vendors shared common electronic replaceable assemblies.

Steerable Antenna.- Dalmo-Victor has indicated a preliminary design concept freeze by February 1, 1965. Development of an experimental model has been deleted from the current schedule. RF and IR tracking techniques, in conjunction with inertial stabilization, are being evaluated.

Erectable Antenna.- RCA has funded two companies to perform studies of fabric requirements and techniques for producing a product that meets the reflector structural tolerances. The rib construction was revised to a box type construction which GAEC considers to be more desirable than solid members.

Diplexer.- A preliminary contract was issued to Rantec. Approval of the procurement specification by GAEC is pending receipt of the trade-off involved in increasing the allowable insertion loss to save weight.

VHF Antenna System.- The VHF antenna system was redefined as a result of the M-5 mockup review. A third frequency of 279.0 Mc was added. This will require a redesign of the VHF inflight antenna matching network, the addition of a channel to the diplexer, and a design of the EVA antenna (a sleeve dipole above the vehicle).

VHF Inflight Antenna.- The added frequency will not alter the antenna design although the matching network will require complete reevaluation. Preproduction drawing release is expected by mid-January 1965.

Multiplexer.- A breadboard of the multiplexer was successfully tested electrically. A design freeze is pending delivery of castings to RCA for verification of the mechanical interface.

Signal Processor Subassembly.- Two experimental models of the audio center and PMP (Block I CSM type) were delivered to RCA to support the communication subsystem bench test. A complete breadboard of the signal processor, completed in December, is being tested. The signal processor is being put in cordwood form for mechanical, thermal, and electrical testing.

VHF Equipment.- All experimental model VHF transmitter-receiver units have passed acceptance testing and were delivered. Unit 1 completed acceptance testing on October 21. It will be used by RCA Engineering. Unit 2, a spare, completed acceptance testing on December 18. Unit 3, which will be used by RCA integration, completed acceptance testing on December 22.

S-Band Transponder.- S-Band transponder experimental model 1 was shipped to RCA on December 11. Acceptance testing of experimental model 2 was completed on December 22.

Seven sets of special test equipment (STE) were assembled. However, the drawer which holds the transponder and the power control and monitoring board is being redesigned because of the redirections on packaging and development schedules.

Work was started on an eighth unit of STE to support the new development schedule from LEM.

S-Band Power Amplifier.- S-Band power amplifier experimental model 1, which was delivered to RCA before this quarter, had two power supply failures. The unit was returned to Raytheon for repair and to determine the cause of the failures.

Operational Instrumentation Subsystem

Water Quantity Measuring Device.- An invitation to quote (ITQ) was issued for the water quantity measuring device for the ECS. Proposals from Huyck Systems, Inc., and Electro Optical Systems, Inc., are being reviewed.

Signal Conditioning Electronics Assembly (SCEA).- Packaging concepts were reviewed for the signal conditioning electronics assembly (SCEA). The plug-in subassembly concept was selected as the best. ITQ's were distributed with a required response by mid-January 1965.

Pulse Code Modulation and Timing Electronics Assembly (PCMTEA).- The pulse code modulation and timing electronics assembly (PCMTEA) preproduction models 1 and 2 were fabricated. Model 1 successfully completed acceptance testing at the vendor, and acceptance testing of model 2 was initiated. Model 2 is slated for interim use in subsystem compatibility testing. It will ultimately be used in in-house spacecraft 1. Fabrication of the first production model has started. This unit will be utilized in the pre-qualification program at the vendor. Three sets of STE were completed and are in final test.

Caution and Warning Electronics Assembly (CWEA).- A contract for the caution and warning electronics assembly (CWEA) was negotiated and signed with the Arma Division, American Bosch Arma Corporation. Although the agreement was on fixed price, incentives based on weight, power, and delivery were included. The vendor started preliminary designing.

Data Storage Electronic Assembly (DSEA).- The contract for the DSEA has been negotiated with Leach Corporation. Incentives on the details of weight, power, and delivery were agreed upon and will be added to the basic package. Formal sign-off is expected by mid-January 1965.

Instrumentation/Communication R and D Subsystems

The following vehicles have been scheduled for IESD GFE for development flight instrumentation (DFI) communication subsystems:

Vehicle	Anticipated delivery of DFI to GAEC
FTA-1	March 15, 1966
FTA-2	June 11, 1966
LEM-1	January 15, 1966
LEM-2	April 15, 1966
LEM-3	June 15, 1966
HS-1	August 15, 1965
LTA-8	October 1, 1965

Measurement lists for Block I vehicles HS-1, LTA-8 and LEM-1 and Block II vehicles LEM-2 and LEM-3 were received from GAEC. Resulting hardware lists were prepared. Complete technical information on transducers was not received from GAEC. A meeting with GAEC personnel will be arranged in January to resolve detail technical information.

Requirements for DFI GFE hardware for LTA-4 and LTA-7 were cancelled.

Television Subsystem

The contract for the development of the TV cameras was signed. The contractor (Westinghouse) completed the preliminary design phase including the construction of a breadboard camera.

A sync format utilizing a frequency burst was developed and evaluated in the laboratory. The sync approach obtained an increase in signal to noise (S/N) of both the picture signal and the sync signal over the old amplitude sync format. Accordingly, the new sync was officially incorporated into the camera.

A high resolution mode of operation was added to the TV camera to double the resolution capabilities. Transmission of scientifically valuable pictures will now be possible over the same 500 kc analog bandwidth.

Radar Subsystems

LEM Landing Radar.- The breadboard landing radar was completed on December 17, 1964. Bench test evaluation of the unit, now in progress, should be completed by February 1, 1965. The unit will begin a three month flight test at Ryan on March 1, 1965. MSC, GAEC, and RCA have reviewed the preliminary flight test plan and will approve the final plan at GAEC on January 20, 1965.

LEM and CSM Rendezvous Radar System.- The breadboard model radar was completed, and the antenna and electronics assemblies are being integrated for bench test evaluation at RCA.

Plume Effect Study Program.- MSC-WSMR was requested to review the results of the Surveyor T-2 tests utilizing the Ryan landing radar systems. Hughes has attempted to isolate the vibration and plume effects on the T-2 test vehicle at Holloman Air Force Base by suspending the landing radar with a rubber-band type suspension system. MSC will review these tests to determine necessity of similar tests on the LEM radar systems.

Development Test Program.- GAEC has requested 13 000-foot test ranges at both Kennedy Space Center (KSC) and MSC based on the assumption of a 25-foot aperture. On January 14, 1965, a meeting will be held at KSC to review the present Gemini test range capabilities and to postpone construction until the maximum distance needed can be determined by MSC. The MSC boresight and test philosophy will be presented to GAEC on January 20, 1965, and to RCA on January 21, 1965.

Scientific Equipment

Grumman began a study to determine methods of carrying a radioisotope power supply as part of lunar landing scientific equipment. The power supply will support experiments of the moon after departure of the LEM. The power supply produces 50 watts of power but generates 1000 watts of waste heat for the entire mission. It is the lightest and the most versatile power source if the waste heat can be controlled. Tentative location of the power supply will be at the surface of the scientific equipment stowage compartment. In that location the descent stage can accept approximately one-third of the waste heat; the remaining heat will be radiated after translunar injection and will be dissipated through a coolant loop to the Saturn instrument unit prior to injection.

The descent stage scientific equipment compartment volume was recently increased from 12 to 15 cubic feet.

NAA and Grumman have agreed on interfaces from the sample return containers. The containers will slide into position on light tracks and will be secured to the spacecraft by four pins.

ADAPTER

Manufacture of the first spacecraft-launch vehicle adapter (SLA) was completed at the NAA plant in Tulsa. The first adapter will be shipped in January 1965 to Marshall Space Flight Center (MSFC) for use on a dynamic test article. All adapters are on schedule.

EXTRAVEHICULAR MOBILITY UNIT

Work continued on all the outstanding contract tasks for the pressure garment assembly (PGA), the portable life support system (PLSS), and other extravehicular mobility unit (EMU) components.

After the bimonthly EMU contract status review, the model A-5H PGA development configuration was firmed. A composite mock-up will be ready for review on March 1, 1965, and three final A-5H assemblies will be delivered to Crew Systems Division on June 1, 1965. This configuration will include a soft shoulder/elbow joint, a fixed visor bubble-type helmet, multiple (inlet and outlet) gas and water connectors, an improved hip/thigh joint, and a soft boot. Other EMU developments include a preliminary configuration for a soft goods meteoroid protective garment (MPG), revision of the extravehicular thermal garment (ETG) design to improve donning and reduce bulk, and completion of the Apollo EMU specification.

X-ray mobility analysis continued to yield important information for improving joint design. A study of joint range requirements for suited performance in the CM was completed.

A much improved palm restraint, developed by David Clark Company, was incorporated into a PGA glove. This palm restraint allows greater freedom and dexterity.

A change order for additional work on the tasks included in the present contract is being negotiated. An engineering change proposal is also being negotiated to procure additional hardware and component prototypes to support test programs at GAEC, NAA, and NASA. The EMU contractor delivered four A-4H training suits to NASA during this period. A change classification system was instituted to assign priorities to the correction of discrepancies found during suit inspection, test, and evaluation.

In-house development of a nonrotating, non-nodding PGA helmet was undertaken to derive a more practical and acceptable helmet design. The resulting configuration promises improved visibility, comfort, freedom of head movement, and reduced size and weight.

A series of studies were successfully conducted using LEM and CM mock-ups and the KC-135 aircraft to evaluate the capability of suited astronauts to perform required mission tasks.

Procurement of hardware for the development model liquid loop portable life support system continued. Several problems have resulted in a 2 to 3 month slip in the delivery schedule of the development unit to NASA; however, the slip will not seriously affect major end item milestones.

As a result of an evaluation of the A-4H development thermal garment, several major modifications have been incorporated in the garment design to improve donning techniques and reduce bulk. The changes will be reflected in training garment deliveries scheduled for early February 1965. These modified garments will be incorporated into a space environment simulator test program for thermal performance evaluation.

Testing of the third model liquid cooling garment was initiated on November 2, 1964. The testing will continue into the first quarter of 1965. Preliminary information indicates satisfactory performance.

The PLSS evaluation test unit produced by Lockheed was accepted by Crew Systems Division on October 21, 1964. The unit will be used for evaluation testing of the major EMU subsystems. The tests are scheduled to begin in May 1965.

The decision to use modified Gemini suits in Block I Apollo flights has been implemented. Modifications to interface the suit with the electrical and mechanical characteristics of the CM were made. A helmet visor protector for intravehicular wear, velcro fasteners on the foot soles, and a change in the pressure relief valve to be compatible with the CM-ECS were also added. The gas disconnects and bioinstrumentation connectors were relocated to eliminate interference with the support and restraint system.

An amendment to the Gemini contract was negotiated with the David Clark Company for design and fabrication of one prototype suit, to be delivered June 1, 1965, and for contractor services to initiate spares and aerospace ground checkout equipment.

LITTLE JOE II

On December 8, 1964, Little Joe II launched the BP-23 payload at WSMR. (See figure 6.) The launch vehicle trajectory closely agreed with the predicted trajectory, but the open-loop control system used more hydraulic fluid than expected, resulting in a reduced pitch-up capability at abort. This, however, did not seriously affect the spacecraft flight test.

Little Joe II launch vehicle 12-51-2 entered manufacturing acceptance evaluation at General Dynamics/Convair on December 16, 1964. The launch vehicle is on schedule for Mission A-003 (BP-22).

Plans are now being solidified for the joint General Dynamics/Convair-NASA control system hardware simulation to verify control system gains and filters for the 12-51-2 vehicle. This simulation will be similar to that conducted for the 12-51-1 vehicle before the December 8 flight.

DESIGN INTEGRATION

MSC is preparing digital thermal analyzer computer programs for the CM, SM, LEM ascent, and LEM descent stages of the Apollo spacecraft. To date, a fairly detailed and checked out SM network is completed. The LEM descent stage network has not been fully qualified, and the LEM ascent and CM networks are being developed. These programs will determine the temperature limitations on the Apollo program missions consistent with the directed Apollo thermal control management.

A complete documentation of thermal environment and associated thermal problems and proposed solutions for all Apollo antennas has been completed.

The spacecraft weight status is shown in table I.

CREW INTEGRATION

Command Module

The Block II CSM crew compartment primary lighting system will employ electroluminescent (EL) sources integral to the display and control panels and instruments. The secondary system will employ incandescent floodlighting. This concept is a significant improvement over Block I which used floodlighting only for the primary and secondary systems. The Block II concept is also compatible with the LEM which employs the EL lighting concept.

The Greenwich mean time (G.m.t.) clock on the CSM main display console (MDC) was replaced with a total elapsed time display in Block I and a total elapsed time plus a phase elapsed time display in Block II. The G.m.t. clock will still be used at the lower equipment bay navigation station. This change was made because the elapsed time from lift-off will be used as the time reference for coordination of Apollo Flight Operations. In addition, the elapsed time is independent of G.m.t. at lift-off; it is the ultimate standard for plotting consumables consumption; it is non-repeating and requires no date correlation; it is more meaningful to operating personnel; and it requires no conversion to G.m.t. or vice versa.

A prototype of the NAA crewman's optical alinement sight was reviewed at MSC. Further review and evaluation of this device will be conducted at Langley during the CM active docking simulation. This device is a collimated sight which will be mounted on the CM docking window frame to aid in docking.

Program planning for the Phase II Apollo centrifuge program was completed. The program is scheduled to be conducted in the MSC Flight Acceleration Facility in December 1965, to verify spacecraft and crew equipment design compatibility with the crew during accelerations.

The Block I and Block II CSM System Specifications, Master End Item Specifications, and the main display console layout drawings have received considerable attention to ensure that they reflect the proper design requirements.

TABLE I.- APOLLO SPACECRAFT WEIGHT STATUS - LUNAR ORBIT RENDEZVOUS MISSION

	Control weight	Previous status 9-1-64	Current weight 12-1-64	Change from last status
COMMAND MODULE	11 000	10 090	10 070	-20
SERVICE MODULE				
Inert	10 200	10 050	10 100	+50
Usable Propellant - Translunar (ΔV = 3870 fps, ISP = 313 sec)	28 440	27 677	27 580	-97
Usable Propellant - Transearth (ΔV_2 = 3915 fps, ISP = 313 sec)	10 070	9 567	9 580	+13
TOTAL SERVICE MODULE	48 710	47 294	47 260	-34
LUNAR EXCURSION MODULE				
Descent Stage				
Inert (including residuals)	3 865	3 987	3 966	-21
Usable Propellant (ΔV_3 = 7385 fps, ISP = 301 sec)	15 975	15 917	15 792	-125
Ascent Stage				
Inert (including residuals)	4 650	4 581	4 509	-72
Usable Propellant (ΔV_4 = 6646 fps, ISP = 303 sec)	5 010	4 946	4 914	-32
TOTAL LEM	29 500	29 431	29 181	-250
ADAPTER	3 800	3 700	3 700	-
SPACECRAFT INJECTED WEIGHT	93 010*	90 515	90 211	-304
LAUNCH ESCAPE SYSTEM	8 200	7 945	7 980	35
SPACECRAFT LAUNCH WEIGHT	101 210	98 460	98 191	-269

*Allowable Injected Weight = 94 000 pounds

NASA-S-64-1710

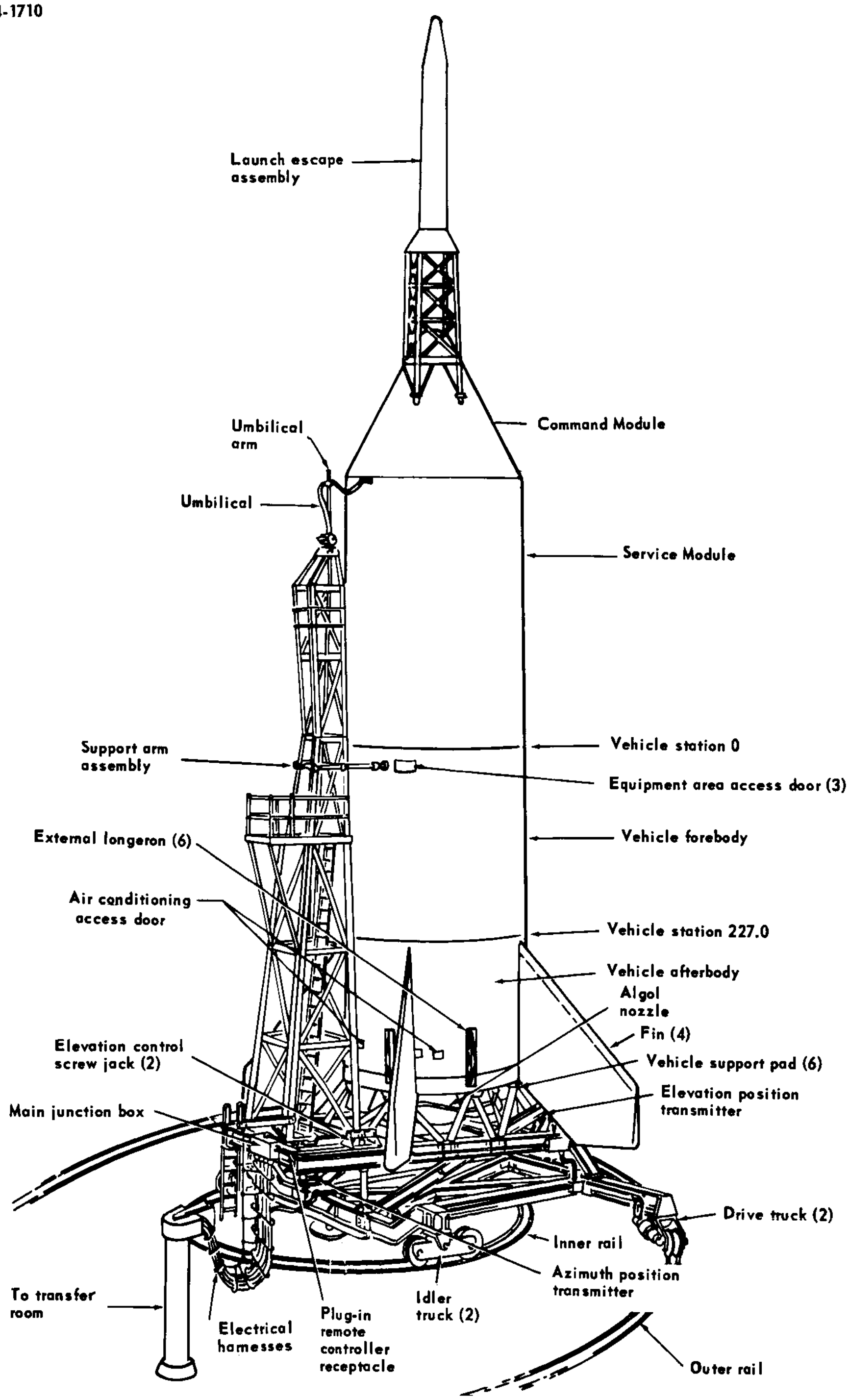

Figure 6.- Little Joe II launch vehicle.

Lunar Excursion Module

The Crew Station inspection during the M-5 mock-up review, revealed that the crew equipment, controls, displays, and lighting were generally acceptable. Since the review, the contractor has been making the requested changes in the main pilot and co-pilot instrument panels and in the size and mountings of the first flight director attitude indicator (FDAI). Several subsystems definition changes have modified the control and display panels. Firm display requirements and arrangements will be approved in January 1965 as subsystem configurations are completed.

During this period, NASA Working Paper no. 1147, "Lunar Landing and Site Selection Study, Phase II" was published. It describes a free flight simulation of the pilot's ability to select and commit to a landing site while under various lunar brightness levels and over simulated lunar terrain.

After the MSC review of controls and displays subsystem test logic, agreements with GAEC were reached on reliability testing, qualification, level of development testing at the vendors subcontractors and GAEC, and quantities of subsystems required.

TRAINING

Training Equipment

Major hardware received by the Apollo mission simulator (AMS) subcontractor include the telemetry console, associated telemetry simulation equipment, and the DDP-24 computers with their peripheral equipment. The AMS program entered a period of intensive drawing release and computer programing efforts. The task of generating tapes to be used as the signal source for launch simulations was accepted as a NASA responsibility. A task group was formed to coordinate this effort. Also, the orbital position indicator was deleted as a requirement on the AMS.

Systems Training

NAA fabricated, tested, and delivered the SCS, electrical, and ECS CSM systems trainers to MSC. The trainers were installed and are now operational. The sequential and propulsion CSM systems trainers are nearly complete. They will be tested, accepted, and delivered in January 1965.

A series of Apollo spacecraft systems courses was presented at MSC during October and November by instructors from the NAA Logistics Training Department. The courses will be repeated at a later date.

AC Spark Plug surveyed NASA requirements for G&N training. The results of the survey will be incorporated into a Training Requirements Analysis.

ENGINEERING SIMULATION

The MSC Guidance and Control Division lunar landing simulation was completed except for a preliminary study of the effect of radar velocity errors on pilot touchdown performance. The major objectives of this study were to (1) determine the feasibility of using a digitally driven attitude indicator, (2) evaluate a modified (zero-overshoot) rate command-attitude hold control mode, (3) determine the effectiveness of a mechanical probe in ascertaining engine shutdown altitude, (4) evaluate and determine the best means of providing a rate of descent control mode, and (5) evaluate a proposed reference trajectory for manual landing approaches. An analysis of the data obtained during this study is now underway.

A simulation study of pilot-controlled atmospheric entires of the Apollo vehicle using backup display information has been completed by the Guidance and Control Division. The primary objective of this study was to determine if entry monitoring and takeover control could be accomplished with a single G-meter and a roll position indicator. The results of the study, which indicated an affirmative answer to the primary objective, have been documented in MSC Internal Note 65-EG-1, dated December 30, 1964.

The GAEC III-B (separation and docking, hover and landing) simulation underwent static and dynamic checks during December and is expected to be operational with all peripheral equipment about February 1, 1965. The II-B simulation (ascent, descent, and abort) is still being assembled. System checks will start March 1, 1965. The full mission engineering simulator (FMES) was originally scheduled to be an entirely digital simulation using an IBM 7094-II computer. However, it is now anticipated that the simulation will be required to use analog equipment as well as the 7094, primarily because in the Z-transform approach to programing, certain dynamic functions failed to cause the expected reduction in computer memory requirements.

NAA presented the simulation program for FY 65 to MSC in October. This program, as approved by MSC, involves a combined effort on the part of NAA and Honeywell, and further provides for the purchase of a flight table and a limited visual display. The simulation program was based on a combined systems design verification (CSDV) hardware study and a separate hybrid computer simulation study. The revised report for this program was subsequently received from the contractor.

The results of the NAA entry 2 study were presented at MSC. The entry 3 study was started and completed this quarter. A 201 mission hybrid simulation was started at NAA and work progressed on assembling the CSDV simulator for 201. Flight operations ground controller personnel are to participate in this simulation following system checkout.

The LEM active docking simulation study at Langley Research Center (LRC) was completed, and study results are to be presented at MSC in early February. Preparations are now underway for the CSM active portion of this docking study. LRC also assembled and continued to checkout a simulation for visual alinement of the CM following a LES abort.

GROUND SYSTEMS ENGINEERING

ACCEPTANCE CHECKOUT EQUIPMENT - SPACECRAFT

Three acceptance checkout equipment-spacecraft (ACE-SC) stations were delivered. Another station is being tested at General Electric, Daytona, in preparation for acceptance and shipment. ACE-SC station NAA no. 1, accepted last quarter, was used to checkout the GSE and ACE-SC carry-on equipment and to complete integrated systems tests on BP-14. The station began a planned retrofit period in mid-December. The station will be operational again with BP-14 by January 15, 1965.

ACE-SC station NAA no. 2 passed the 72-hour acceptance test in Daytona with only 3 minutes of down time during the test. NASA acceptance was completed December 1, 1964 at NAA, Downey. Since that time, validation of programs based on ACE-SC station no. 1 has begun. GSE checkout and program validation will be completed in February. Spacecraft checkout will begin in March 1965.

ACE-SC station NAA no. 3 also completed the 72-hour acceptance tests at GE Daytona during November. The station was delivered to NAA Downey in December. Acceptance tests are scheduled to begin January 20, 1965. The station is on schedule and acceptance is expected by February 1, 1965.

ACE-SC station MSC no. 1 will be delivered next. This station is currently on schedule undergoing tests at GE Daytona.

GROUND SUPPORT EQUIPMENT

NASA evaluated the requirements for 349 models of GSE submitted by NAA for contractural coverage; 295 were approved with quantity change, and 54 disapproved.

Electrical.- The program review and contract definition of GSE requirements were completed with AC Spark Plug. Twenty-two test stations will be required.

Numerous items of aerospace ground equipment (AGE) were reviewed at Kelly AFB by NASA, NAA, and GAEC for potential use on the Apollo program. The contractors reviewed and made recommendations to NASA on those items which could be substituted for GSE. Eleven items have been identified and shipped to GAEC, Bethpage, and WSMR.

NAA agreed on the GSE qualification program. Cost of the program has been reduced from a proposed $4.8 million to a basic price of $212 000. Minimal additional costs may result if further testing is necessary.

Three GSE concept reviews were held at NAA during the reporting period. Sixty-nine items were reviewed: 54 approved, 3 disapproved, and 12 held in abeyance.

Mechanical.- The design concepts of 49 mechanical models were reviewed during this report period: 38 were approved, 2 were deleted, and 9 items were held in abeyance.

Procedures for control of government furnished property (GFP), for GSE identification and traceability requirements, for ignition proof requirements, and for identification of mechanical GSE requiring EMI tests were developed and implemented. The concept for SC cryogenic servicing was changed from a recirculation method to a vented method, which resulted in a $500 000 savings in GSE and reagents.

Logistics.- Arrangements were made with Department of the Army to transport LEM adapters from Tulsa to the test sites by CH-47A helicopter. The air worthiness of the CH-47A for this lift was confirmed during a test program at Tulsa. After testing was completed, the adapter was transported from Tulsa to KSC. Helicopter movement of LEM adapters is continuing on a regular schedule.

Preinstallation acceptance (PIA) testing requirements for spare parts were clarified for NAA, GAEC, and MIT. PIA testing on spares will be conducted only to the extent that existing facilities and test equipment allow.

CHECKOUT

The Apollo Checkout Criteria MSC-COC-1, with contractors and other MSC organizations comments included, was issued on October 22. The document is being reviewed by MSC for issue as a Center-wide document. Also, a preliminary draft of the Apollo GSE Criteria Document was prepared. The first issue is due March 1, 1965.

Schedules have been established for the issuance by the contractors of the ground operations specifications (GOS) for blocks of vehicles and for specific vehicles. The LEM GOS was reissued in December 1964. Present plans require issuance of the CSM Block I and SC 009 GOS next quarter.

OPERATIONS PLANNING

LUNAR MISSION PLANNING

The joint Contractor-NASA Apollo Mission Planning Task Force (AMPTF) has completed the Phase II portion of their study. The following major items were documented.

Design Reference Mission (DRM).- The DRM is a lunar landing mission which is to be used by the spacecraft contractors as a common basis for weight reporting, electrical power reporting, reliability modeling, et cetera. The DRM is documented in three volumes: (1) Mission description and trajectory, (2) prelaunch sequence-of-events, beginning with rollout from the vertical assembly building, and (3) in-flight sequence-of-events.

Mission-Related Design Requirements for Spacecraft Subsystems.- The subsystem mission requirements were documented for all LEM subsystems. Work is in progress for all CSM subsystems.

Abort Trajectory Summary.- The results of abort trajectory studies were presented parametrically to be generally applicable to a range of missions.

Lunar Excursion Module (LEM) Contingency Analysis.- The LEM subsystems were analyzed to determine the effects of single failure events on the ability of the LEM to continue or safely abort the mission. A similar analysis was performed for the spacecraft assembly.

Subsystem Requirements

MSC has formally requested GAEC to provide for six PLSS recharges and three rechargeable, replaceable PLSS batteries.

ASPO has formally requested the MSC Instrumentation and Electronic Systems Division to delete the requirement for a lunar extravehicular astronaut (EVA) to CSM communications link in the LEM-CSM VHF system. The requirement to communicate with the CSM from a lunar EVA is handled through the LEM – Manned Space Flight Network – CSM S-band relay.

DEVELOPMENT MISSION PLANNING

Spacecraft missions objectives, ranked in order of importance, were published for Apollo missions 201, 202, 204, 206, 501, and 502. As a result, preliminary trajectories were established for 201 and 202, and are being generated for 204, 205, 501, and 502.

TEST PROGRAM PLANNING

GROUND TEST PROGRAM

A review of the LEM ground test program was conducted to reduce the peak GAEC manufacturing work load and to improve ground test support of flight test operations. As a result, the program was streamlined by deleting the equivalent of four LEM test articles (LTA) and by revising the testing arrangement of the remaining test articles to specific test categories.

Test articles LTA-6, LTA-7, LTA-9 and the electrical systems integration vehicle were deleted and the following test article assignments were made:

LTA-1 House spacecraft no. 1 (electrical systems integration)

LTA-2 Launch vehicle dynamics test article

LTA-3 Structural test article, static and dynamic

LTA-4 House spacecraft no. 2 (electrical systems integration)

LTA-5 Propulsion and power test article

LTA-8 Thermal/vacuum environment test article

LTA-10 LEM/SLA structural test article

The LTA master development schedule is shown in table II. GAEC and MSC formally agreed on this revised program during the November 25 program review.

SPACECRAFT TEST

GROUND TEST ARTICLES

Boilerplate 14 - House Spacecraft No. 1

The communications, flight instrumentation, reaction control, and service propulsion subsystem components were installed in BP-14 and checked out. The vehicle was connected to ACE-SC Ground Station NAA no. 1 and combined systems checkout of the electrical power, environmental control, communications, flight instrumentation, spacecraft control, service propulsion, and command and service module reaction control subsystems was completed. No major difficulties were encountered, although several necessary changes to GSE were identified. These changes are being implemented and will be completed before resuming system checkout operations. BP-14 is being reworked to install the mission sequencer. The vehicle is scheduled to resume operations to support A-201 mission using ACE-SC station NAA no. 1 in mid-February 1965.

Boilerplate 27 - Second Dynamic Test Article

The LES and CSM were fabricated during this reporting reporting period. The CM was shipped to MSC on October 2, 1964, followed by the SM on October 7, 1964. The LES was shipped to MSFC on November 20, 1964, where it was stored to await the rest of the space vehicle payload. Shell and panel modal testing of the CSM was conducted at MSC. Some difficulties during early testing resulted in poor data correlation. Changes were made to the test setup to simulate fuel and oxidizer tankage loads and the launch loads on the radial beams of the SM. These

TABLE II. - LEM TEST ARTICLE MASTER DEVELOPMENT SCHEDULE

NASA-S-65-1401

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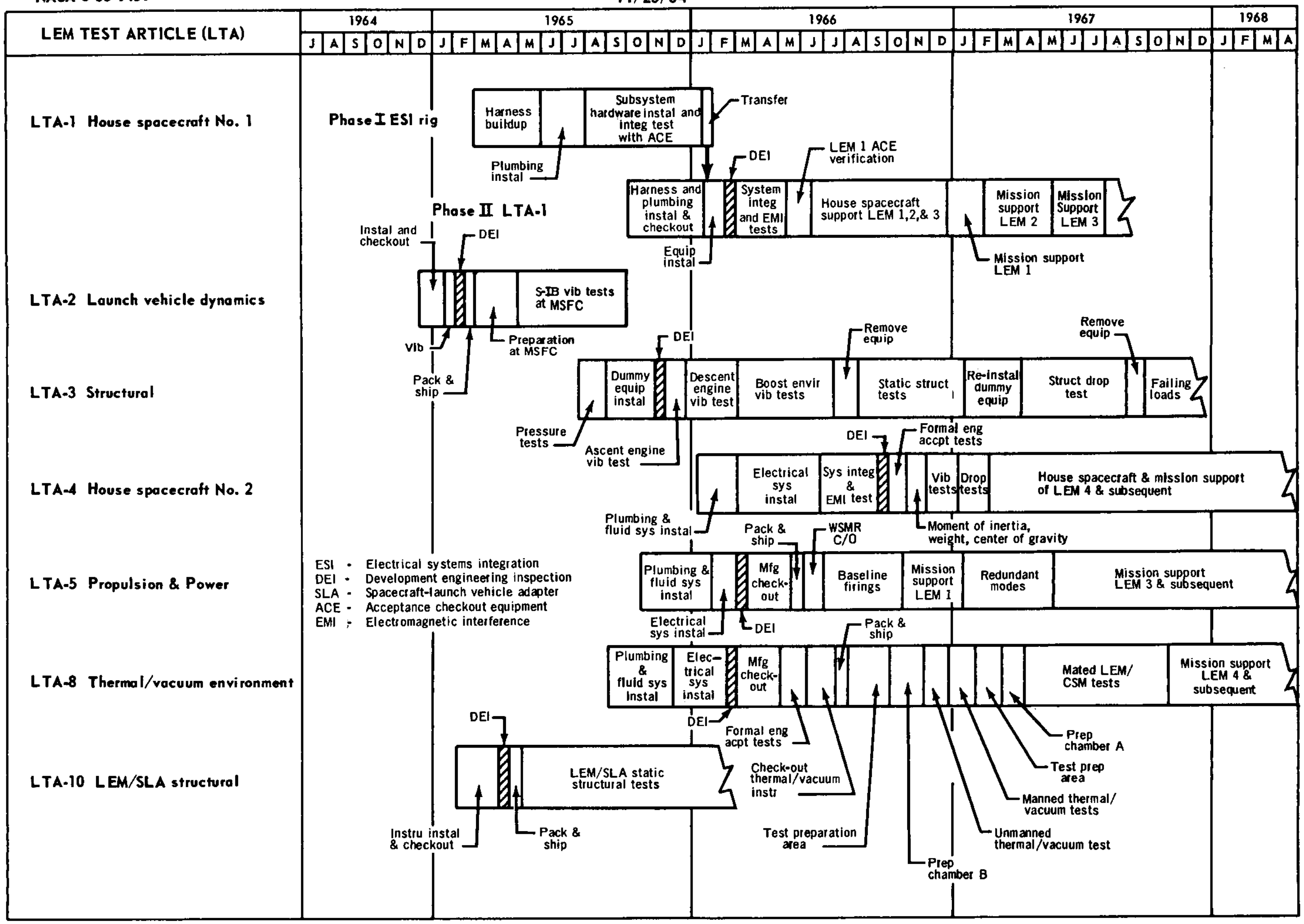


changes, as well as changes in the excitation attachment, have resulted in consistent data. Shell and panel modal testing will be complete in early January 1965 and will be followed by axial and body bending modal tests. Shipment to MSFC is scheduled for February 12, 1965.

The SLA is nearly complete. A hardware and data package review was held at Tulsa on December 14, 1964. Five Requests for Changes (RFC) were submitted; four were accepted. Resolution of the RFC's will not delay the January 15, 1965, delivery of the BP-27 SLA to MSFC.

Spacecraft 001 - Service Module Ground Test Vehicle

SC 001 will be utilized to investigate the performance characteristics of the subsystems and their associated GSE. SC 001 contains the service propulsion, reaction control, electrical power, cryogenic gas storage, and instrumentation subsystems. SC 001 completed manufacturing in October 1964, and a development engineering inspection (DEI) followed on October 30. Final acceptance checkout operations at Downey were initiated after the DEI. These operations will verify the integrity of the on-board components of the individual subsystems. A combination of system measuring devices and ground support equipment was utilized for checkout. The SC configuration in the Downey checkout did not have the fuel cells, cryogenic storage tanks, SPS engine, or RCS Quads installed. These items will be shipped directly to PSDF after their individual acceptance tests. The Downey checkout operations were completed on December 17, 1964; the SC 001 was flown to Holloman Air Force Base on December 18 and then trucked to PSDF on December 19, 1964. After the receiving inspection, the spacecraft was installed into its test stand on December 31, 1964. Hot propulsion testing of the service propulsion subsystem (SPS) is to start on schedule during the first week of February 1965.

Spacecraft 008 - Environmental Test

Closeout weld of the CM inner crew compartment was completed, the CM secondary structure girth shelf completed the major portion of its buildup, welding of the aft heat shield panels was completed, the CM apex and forward heat shield assemblies were completed, and the crew compartment heat shield forward and aft sections were joined.

The SM aft bulkhead and radial beam were installed. The SM was then moved to the second assembly jig to begin ECS and EPS radiator panel installation.

The preliminary release of the SC 008 Contract End Item Specification, SID 63-700, dated November 25, 1964, was received, and comments were forwarded to NAA on December 22, 1964. The SC 008 Test Plan, SID 64-1920, dated November 2, 1964, was received December 31, 1964 from NAA. Contractural direction was provided to NAA stating that, except for configuration differences already authorized or required due to unique mission and test characteristics, SC 008 would be configured like SC 012. It also required that NAA present a detailed 008 versus 012 configuration comparison to MSC for approval.

LTA-2 – Dynamic Test Article

LTA-2 is nearly fabricated. The GAEC test plan was reviewed and approved. Dynamic modal testing is scheduled to start in late January 1965 at GAEC. The LTA-2 is scheduled for shipment to MSFC in February 1965.

Spacecraft 006 – House Spacecraft No. 2

Structural fabrication and assembly of the CSM was completed. The contractor was directed to configure SC 006 like SC 012. This direction required that the spacecraft wiring harness be modified to accept the Block K SCS instead of the Block H and to accept the 100 series G&N. Start of subsystems installation is thus delayed to the spring of 1965. The adverse effect of this change was eased by substituting a brief quality verification vibration test (QVVT) for the planned vibration proof test.

House spacecraft support of SC 011 and 012 is under review and will be established in the next report period. Subsystem deliveries are progressing on schedule although electrical connector deliveries remain behind schedule. The CM heat shield ablative material lay-up is in progress at AVCO. Delivery is expected to be on schedule.

Boilerplate 29 – Flotation Vehicle

BP-29 is on schedule; however, a 60-day delivery delay is planned in order to add postlanding equipment to the exterior. This equipment will allow an early evaluation of open sea environmental effects on postlanding components.

Boilerplate 1 – Earth Landing Development

BP-1 was dropped approximately 20 times at NAA to support water landing acceleration and corresponding pressure time history investigation. Data from these drops were used for comparison and verification with the $\frac{1}{10}$ and $\frac{1}{4}$ scale model drop programs.

Boilerplate 28 – Earth Landing Test Bed

During the first BP-28 drop test on October 30, 1964, the vehicle partially submerged at impact, bobbed to the surface, and then sank. A comparison of critical landing conditions versus the actual BP-28 conditions is shown on figure 7. The vehicle was recovered from the water. A post-test analysis of the heat shield, aft bulkhead, and component parts indicated a massive shear and buckling failure of the boilerplate aft heat shield and aft bulkhead. Also, much of the simulated equipment within the crew compartment came loose.

Cameras and approximately 140 channels of instrumentation were utilized for this test drop. The data was reduced and transmitted to MSC for evaluation. Although the BP-28 drop did not allow efficient correlation or direct application of the data to the spacecraft structural design, the drop did indicate the need for a structural redesign. Subsequent spacecraft designs will be tested on BP-28 with actual rather than simulated lower heat shield and aft bulkhead components. The next drop of BP-28, about February 1, will utilize a beefed-up spacecraft heat shield and a spacecraft aft bulkhead. The proposed test program for BP-28 now consists of six drops with brazed spacecraft components instead of the fifteen previously planned with simulated heat shields.

Spacecraft 007 – Acoustic, Flotation, Water Impact, and Postlanding Subsystems Qualification

As a result of the SC 007 design review held at NAA on December 16, 1964, the flotation tests planned at NAA were deleted. The flotation tests will now be performed concurrently with the postlanding subsystems qualification program at MSC and in the Gulf of Mexico. Recovery and location aids tests and uprighting aid qualification tests are supporting SC 009.

MILA Facilities Verification Hardware

The NAA facilities verification hardware will be ready for use at MILA approximately $2\frac{1}{2}$ months before it is required to support SC 009. Design and kit definition efforts for the verification vehicle and the fluid test sets are approximately 95 percent complete. Manufacturing and modifications to the vehicle will be completed before February 28, 1965. Fluid test set will be complete in mid-April 1965. The verification vehicle SLA and LES were delivered to MILA and are ready for use.

NASA-S-64-7687

WEIGHT-10,347 LB

CG X^a = 1039.1 IN
Y^a = .8 IN
Z^a = 4.0 IN

MAXIMUM IMPACT CONDITIONS	2 CHUTE	3 CHUTE
HORIZONTAL VEL	48 FPS	48 FPS
VERTICAL VEL	35 FPS	28 FPS
ROLL ANGLE	180°	180°
YAW ANGLE	0°	0°
PITCH ANGLE	9.5°	13.5°
*HORIZONTAL VEL	42 FPS	43.5 FPS
*VERTICAL VEL	41.5 FPS	35 FPS

* RESULTANT FACILITY VEL
SIMULATING 8.4° WAVE SLOPE

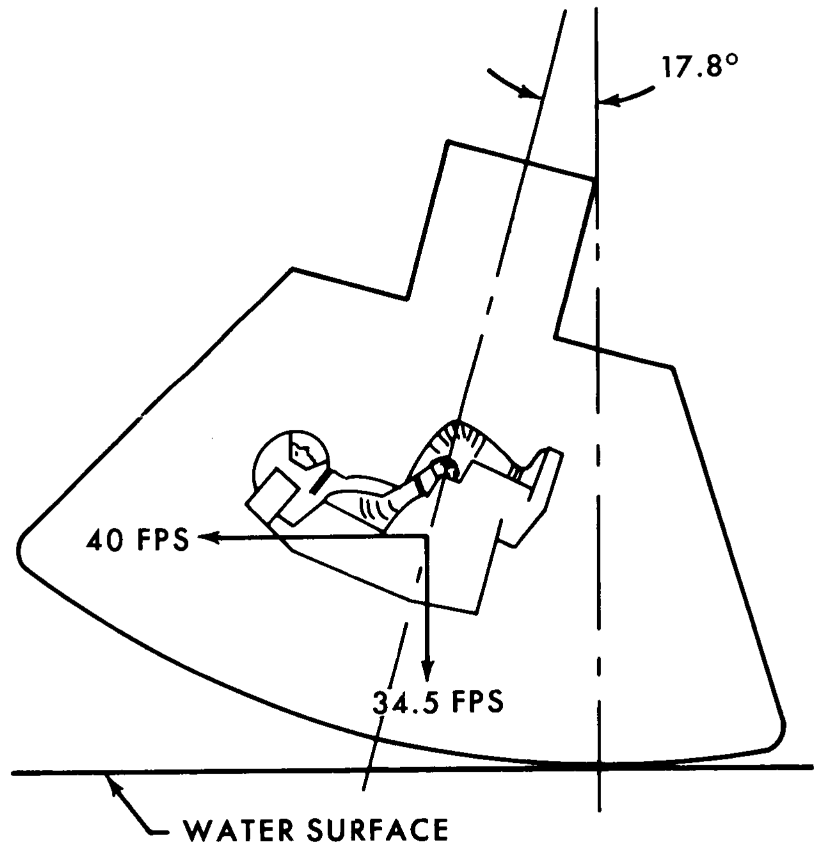


Figure 7.- Boilerplate 28 drop conditions.

FLIGHT TEST ARTICLES

Boilerplate 22

The BP-22 flight, a high altitude abort test at WSMR, is scheduled for May 15, 1965. The abort will be initiated at approximately 110 000 feet (msl) which is the upper limit for operation of the canard subsystem. BP-22 will utilize an attitude stabilized Little Joe II launch vehicle with a 3-3 Algol motor configuration.

All manufacturing and system installations are virtually complete, and Apollo test operations factory checkout will start early in the first quarter of 1965.

The development engineering inspection was held at NAA on December 18, 1964.

Boilerplate 23

During October and November 1964, checkout of BP-23 continued and final countdown began on December 7, 1964 as scheduled. The spacecraft was launched at 8:00 a.m. m.s.t. on December 8, 1964. All major test objectives were achieved, and satisfactory engineering data were obtained to verify the abort capability in a maximum dynamic pressure region while approximately launch vehicle emergency detection system (EDS) limits. The launch escape vehicle propulsion was adequate to separate the CM from the SM at an angle of attack from a thrusting launch vehicle, and the canards satisfactorily caused launch escape vehicle turnaround. The reefed dual drogues satisfactorily aided in damping CM oscillations. It was also demonstrated that the boost protective cover requires design improvement to maintain integrity throughout the abort. All other spacecraft and launch vehicle subsystems performed satisfactorily.

Conditions at abort were as follows:

Planned		Achieved
Mach	1.5	1.55
q	780 psf	990 psf
Time	37.5 sec	35.7 sec
Altitude	33 825 ft	31 950 ft
Pitch angle	$-8.3°$	$-4.5°$

The launch vehicle control system will be modified for future launches by doubling the gas and hydraulic fluid capacity.

Boilerplate 23A

The BP-23 command module is being refurbished at WSMR to perform the Apollo pad abort 2 mission. The vehicle will be launched at WSMR during the third quarter of 1965.

Spacecraft 002

Major structural assembly is continuing on SC 002. A fit-check of the CM crew compartment and outer heat shield is scheduled for mid-January 1965. The instrumentation breadboard was delivered from MSC-IESD to NAA-Downey on December 2, 1964. Breadboard testing is proceeding and will support the scheduled systems installation operation.

See table III for the Apollo pad abort launch schedule.

Spacecraft 009

The mission directive for SC 009 was published on December 19, 1964.

A preliminary review of the contractor End Item Specification was held at MSC the last of November.

The service module structural assembly was completed December 26, 1964, and systems installation was started. The command module is in the secondary structure installation phase. Systems installation is projected to begin in February 1965.

Spacecraft 011

The $\frac{3}{4}$ and $\frac{1}{4}$ sections of the forward CM crew compartment were joined; 85 percent of the primary bonding for both the forward and aft crew compartments was completed; and the assembly phase of manufacturing is within $3\frac{1}{2}$ months of completion. All radial beams were joined to the aft bulkhead of the SM.

Preliminary definition studies for mission A-202 have resulted in a planned suborbital flight of about $1\frac{1}{2}$ hours with a total SPS firing time of approximately 230 seconds. Touchdown is expected near Wake Island. Studies have shown that the planned mission will satisfy the primary objectives of evaluating the thermal performance of the CM heat shield during a high heat load entry and demonstrating the compatibility and structural performance of the CSM-Saturn 1B.

Boilerplates 16 and 26

The MSFC modifications of the SM to accommodate the micrometeoroid capsule were completed. The Cape Kennedy operations are on schedule.

RELIABILITY AND QUALITY ASSURANCE (R AND QA)

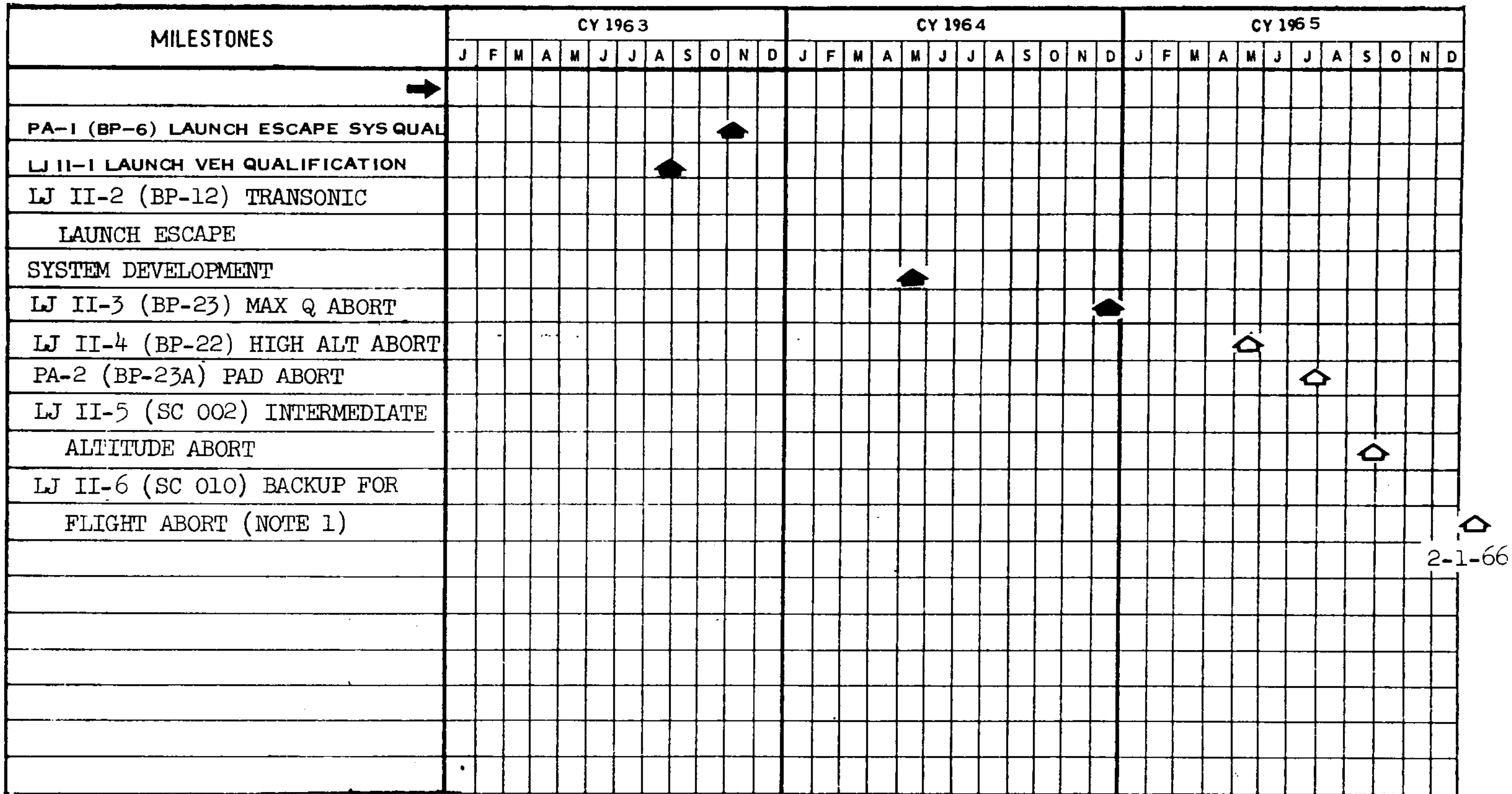
The MSC-ASPO quality assurance program plan was revised, expanded, and reissued. An Apollo spacecraft reliability requirements manual was drafted for review, and is being expanded for final issue in the next quarter.

A schedule of milestones significant to R and QA program management, subsystem development, qualification, end-item deliveries, and missions was issued. This schedule is being updated and will be re-released in the next quarter.

In accordance with MSC direction, NAA has revised the CSM Reliability Program Plan to reflect NPC 250-1 requirements, thus completing the transition from MIL-R-27542 to NPC 250-1 as the standard on all MSC-Apollo prime contracts and major subcontracts. Final MSC review of this plan will be complete in the next quarter.

To best appraise the effectiveness and degree of contractor conformance to the approved R and QA program plans, and to assess the integration of these plans with the Government Agency Quality Plans, a system of orderly audits are to be conducted. Copies of the NASA publication "Manual for Evaluating Contractor Reliability Plans and Performance," June 1, 1964, and the "Surveyors Manual for Quality Program Evaluations," December 1, 1963, have been forwarded to each prime contractor. The ASPO-R and QA audits will be based upon these guideline documents. The plan for conducting these audits was formulated, and will be implemented next quarter. ASPO-R and QA reliability audits will initially be confined to prime contractors, but quality audits will review procedures at the prime and major subcontractor level, in conjunction with RASPO and GIA personnel. An audit of NAA/S&ID quality procedures and controls were conducted during this quarter by representatives of MSC and MSFC.

TABLE III.- APOLLO PAD ABORT AND LITTLE JOE II LAUNCH SCHEDULE (As of December 31, 1964)



Notes: 1. SC 010 and LJ II-6 LAUNCH VEHICLE ARE PROVIDED AS A POSSIBLE BACKUP FOR BP-22 or SC 002. REWORKED BP-23 WILL BE MADE AVAILABLE FOR PAD ABORT.

NASA FORM 795 DEC. 62

In the past quarter, NAA/S&ID conducted four supplier conformance reviews, eleven supplier pre-award surveys, and thirty-four special process surveys. The program of in-house audits at S&ID continued including audits of product quality, procedures and conformance to procedures, and personnel performance. Some 3000 in-house audits were conducted at NAA.

MSC quality personnel at NAA and GAEC conducted ten audits on products and special procedures at various subcontractor facilities during this quarter.

An MSC Operational Readiness Program Plan for the Apollo spacecraft and associated GSE was prepared in preliminary form. Operational Readiness Plans from NAA, GAEC, and GE-ACE were reviewed as part of the planning effort.

An extensive review of the AC Spark Plug (ACSP) Quality and Reliability Program conducted this quarter was followed by negotiations at ACSP on the nature, scope, and expenditure of effort on this program. Preparation for a similar review at GAEC has been initiated.

The latest revision of the MIT/IL Quality Program Plan was reviewed and found, in general, to be still lacking in areas of integrated effort with G&N contractors.

A system to generate and distribute ASPO Reliability Problem Bulletins was put in operation. The primary purpose is to provide a central clearing house to effectively and expeditiously resolve common interest problems or potential problems. The first five ASPO Reliability Problem Bulletins were issued during the quarter. They covered problems with certain types of transistors, connectors, and capacitors.

Resolution of soldering requirements between ASPO-R and QA and NAA was achieved through preparation of a document to be used in conjunction with MSFC-PROC-158A. This document was prepared jointly with MSFC. NPC 200-4 was subsequently received and reviewed with NAA against the document described above. It was found that the existing MSC-NAA document contained all the significant requirements of NPC 200-4.

The MSC Crimping Specification MSC-ASPO-C3B has been revised to include NAA inputs and to limit its application to flight hardware and mission-essential GSE only. This revision, MSC-ASPO-C3C, should reduce program costs.

The Apollo spacecraft parts and materials program was started in this quarter. The Phase I study was completed and presented to ASPO Management. Approval was received to proceed with the Phase II implementation program, and work started on the preparation of a control management plan and an accelerated implementation schedule for the entire program. The objectives of this program are to provide the following:

1. Reliability history, test data and performance, information on parts by function and material for future use by the Apollo and follow-on programs.

2. Information for the generation of a parts/materials failure and usage index for periodically assessing the actual reliability of parts and materials while in use.

3. A means for MSC-ASPO management to identify and eliminate duplicate efforts in parts and materials investigations and to evaluate contractor/supplier performance.

4. A resource of technical data and experienced personnel which may be employed for the rapid assessment of the effects of failures and potential failures on the success of the Apollo program.

A program was started to define a uniform, integrated data reporting, analysis, and corrective action system for Apollo spacecraft. The purpose is to define requirements for all quality related data, including success data as well as failure data. Failure data is being received weekly from NAA on magnetic tape. Submittal of failure data on tape from Grumman will begin next quarter to replace the present system of providing copies of actual failure reports to MSC. Failure data submittal from MIT/ACSP is still under negotiation.

Work was started this quarter on defining a proposed MSC-ASPO quantitative approach to reliability assessment, a study has been initiated to determine the feasibility of establishing a reliability math model at MSC for use in trade-off studies, predictions, and study of interfaces between CSM, LEM, LES, launch vehicle, and GSE.

Current reliability predictions for the spacecraft compared to the goals are as follows:

		Mission Success		Crew Safety	
		Goal	Prediction	Goal	Prediction
CSM		.964	.944	.9995	.997
	G&N	.985	.968	-	-
LEM		.984	.90	.9995	.995
	G&N	.994	.992	-	-
Spacecraft		.948	.85	.999	.990

GAEC continued with weight-reliability and configuration trade-off studies. These studies have resulted in a recommended program to cut about 1000 pounds from the LEM. The details of the study were received for review by MSC.

A detailed study and review of the existing NAA qualification program was completed. This was implemented primarily through review of the program as applied to SC 009 with SC 011 and SC 012 to be covered by exception. A formal review of the qualification program and resolution of discrepancies will be conducted at NAA in January 1965.

The Grumman qualification program was reviewed. The GAEC test logic sheets that were developed during the review at Bethpage were rechecked in detail. Grumman was directed to make appropriate changes.

The MSC Qualification Test Ground Rules were revised and were agreed upon by NAA Management.

End-item reliability assessment activity during this quarter was performed primarily for BP-23, BP-22, and SC 009.

For BP-23, the activity included review of the acceptance data package, review of discrepancy reports generated at WSMR for adequacy of corrective action, participation in the pre-FRR and FRR meetings, postflight examination of the hardware, and review of the flight data. All apparent flight anomalies are being studied to determine their significance.

SC 009 activity has been intense. In addition to the qualification program problems discussed above, the End-Item Specification for SC 009, SID 63-701, dated October 20, 1964, was reviewed and critiqued against existing Block I vehicle specifications; recommendations for changes were submitted. A red flag list of items which are either not being qualified or will not be in time to support the SC 009 flight was established. In addition, a study was started to identify all circuit breakers and fuses in the SC 009 configuration and their function and to recommend which should be shunted just prior to flight.

The NASA Headquarters document MD MA 1400, May 20, 1964, "Apollo Test Requirements" was reviewed. Certain changes were recommended to conform to present MSC Apollo program requirements.

An input to the Apollo Master Test Plan was prepared to define qualification test requirements.

PROGRAM CONTROL

PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT)

NAA PERT

A review of each CSM PERT network was conducted at MSC by the Program Control Division, subsystem managers, and vehicle project engineers. Required changes were annotated and reviewed with NAA. All the required changes have been incorporated except those of the instrumentation subsystem network.

The PERT reviews indicated the requirements by all MSC using organizations of updating PERT logic diagrams (networks) at a more frequent interval. NAA is now submitting on a monthly basis updated networks on aperture cards which are reproduced and distributed at MSC.

G&N PERT

The NASA PERT interface control procedures have been implemented within the Block I 100 series G&N program PERT. The Office of Manned Space Flight (OMSF) status reporting graphics (Level III) are now compatible with the biweekly G&N system performance and review reporting graphics. The G&N PERT presently covers 6200 activities during the reporting period.

Future implementation of Block II and LEM G&N Systems PERT pending contract negotiations is planned.

LEM PERT

A final MSC/GAEC review of the ground test program was completed on November 25, 1964. An equivalent of four ground test vehicles was deleted from the program. At the same time, a review of the LEM subsystem test logic and hardware requirements associated with the revised ground test program was held. Agreement was reached on reliability testing, qualification testing, development testing, and sparing quantities. Final approval of the subsystem test program is subject to the resultant cost impact from subcontractors and the joint NASA/GAEC program review scheduled for the first quarter of 1965.

Official direction for incorporating the November 25, 1964 program redefinition into PERT was given to the contractor. Joint MSC-Contractor schedules and procedures were established to guarantee the major PERT revision by February 15, 1965, with minimum interruption of information flow.

In response to earlier direction by MSC, formal in-house and subcontractor PERT operating procedures were established by GAEC.

Apollo PERT

A system is now being implemented to tie NASA Headquarters status reporting of key Apollo milestones directly to contractor PERT submissions. The system is based on a series of hardware-oriented networks which were developed at MSC to reflect the relationship between all major milestones in the Apollo program. Monthly network statuses are summarized from the biweekly contractor PERT reports. An MSC integrated PERT computer run is then prepared to reflect the expected and latest allowable dates of attainment of each milestone. The data from the computer are then transcribed to a schedule format. The primary advantages are that concise information is available on each milestone in the Apollo Program, required manpower is reduced, and documents that provide a quick reference to the logic employed by MSC and the contractor are available.

The current status of the system is as follows:

Networks for Block I CSM and boilerplates were prepared by MSC, and the event numbers for all applicable milestones were frozen in the contractor PERT system. Networks for Block I CSM G&N and acceptance checkout equipment (ACE) were prepared and the resulting milestones were identified within the contractor PERT systems. Networks for Block II CSM, Block II CSM G&N, LEM, and LEM G&N were prepared and plans were made to associate these milestones with contractor PERT as these PERT systems develop. Networks for adapter, Apollo crew systems, crew training, and flight operations were prepared in draft form and will shortly be included in the system.

The operational portion of the system has been used for the MSF submission for three reporting cycles. It is expected to be approved for total implementation in January.

CONFIGURATION MANAGEMENT

MSC Supplement 1, revision A, to the Apollo Configuration Management Manual (NPC 500-1) was completed and transmitted to the major Apollo contractors. Documentation flow procedures and the functions of the affected organizations within MSC were completed and distributed internally.

The Configuration Control Board held its first panel meeting on November 23, 1964. Weekly panel meetings are now being held.

The contractors will submit their internal plans according to Supplement 1 for implementing their configuration management to the ASPO in January and February 1965. It is anticipated that configuration management will be on contract and in operation with the major contractors next quarter.

LEM FACILITIES

The ground data reduction station to support LEM development programs at Bethpage is proceeding on schedule. The MSC/WSMR-PSDF common use laboratory was completed. A DEI for the GAEC/WSMR-PSDF test facility no. 2 is scheduled for early February. Initial firings of the LEM propulsion system will be conducted on this test stand.

SITE ACTIVATION

NAA was directed to activate hypergolic building 1 at MILA to support checkout of SC 009.

The remaining GSE required to support an SPS firing at WSMR in February 1965 was delivered in December 1964.

Astro Data Corporation was selected to provide the system for the LEM data reduction station that supports R&D efforts at Bethpage.

Activation of the manufacturing portion of NAA building 290 at Downey was assigned to site activation personnel. The final assembly stations and system test stations are currently on schedule to support SC 009.

Changes in the delivery schedule of SC 008 to MSC has caused a change in the activation date of the MSC test facilities to support SC 008.

Detailed site activation plans and schedules have been received from NAA and GAEC for test facilities at KSC and WSMR-PSDF.

PUBLICATIONS

NORTH AMERICAN AVIATION, INC.
CONTRACT NAS 9-150

Report number	Subject	Report date
SID-62-384-72	Drawing and Specification List Apollo Spacecraft Complete	Dec. 21, 1964
SID-62-557-11	Quarterly Reliability Status Report	Sept. 30, 1964
SID-62-300-31	Apollo Monthly Progress Report	Dec. 1, 1964
SID-62-99-34	Monthly Weight and Balance Report for the Apollo Spacecraft	Dec. 1, 1964
SID-62-784	Qualification Status List	Oct. 1, 1964
SID-62-1244	Apollo Lunar Excursion Module Performance and Interface Specification	Nov. 17, 1964
SID-62-417	Ground Support Equipment Planning and Requirements List	Nov. 1, 1964
SID-62-435	Apollo Spacecraft Familiarization Manual	Oct. 30, 1964
SID-62-702-1	Apollo Support Plan	Sept. 30, 1964
SID-62-1003	NASA Furnished Crew Equipment Performance and Interface Specification	Sept. 30, 1964
SID-63-313	Apollo Master Spacecraft Specification	Dec. 1, 1964
SID-63-1000	Apollo Manpower Application Report for the Month of Sept. 1964	Dec. 15, 1964
SID-63-573	Apollo Measurement Requirements Boilerplate 23	Dec. 1, 1964
SID-63-572	Apollo Measurement Requirements Boilerplate 22	Dec. 1, 1964

Report number	Subject	Report date
SID-63-701	CEI Detail Specification Part I Performance/Design Requirements Airframe 009 Apollo Spacecraft	Dec. 11, 1964
SID-63-21-24	Monthly Quality Status Report	Dec. 12, 1964
SID-63-143-12W	Pre-Flight Actual Weight and Balance Report Boilerplate Stack No. 23 High Dynamic Pressure Abort Test	Nov. 20, 1964
SID-63-512	Apollo Command Module/Service Module Measurement Requirements Spacecraft 012, 014 and 015	Oct. 12, 1964
SID-63-1147	Apollo General GSE Specification	Nov. 6, 1964
SID-63-143-13	Actual Weight and Balance Report Boilerplate Stock No. 27 Second Vehicle for Dynamic Tests	Oct. 30, 1964
SID-63-511	Apollo Command Module/Service Module Measurement Requirements Spacecraft 011	Oct. 12, 1964
SID-63-509	Apollo Measurement Requirements Spacecraft 009	Oct. 12, 1964
SID-63-507	Apollo Command Module/Service Module Measurement Requirements Spacecraft 006	Oct. 30, 1964
SID-63-693	Project Apollo Contract End Item Specification Boilerplate No. 22	Oct. 19, 1964
SID-63-694	Project Apollo End Item Specification Boilerplate 23	Oct. 9, 1964
SID-64-158	ACE S/C Activation Plan	Dec. 15, 1964
SID-64-1345	CSM Master End Item Specification (Block II)	Dec. 1, 1964
SID-64-2114	Vehicle Test Plan Apollo Mission A-202 (Spacecraft 011)	Dec. 15, 1964

Report number	Subject	Report date
SID-64-1344	CSM Technical Specification (Block II)	Dec. 1, 1964
SID-64-1237	CSM Master End Item Specification (Block I)	Dec. 1, 1964
SID-64-1700	Mass Properties Data Block I Control Weights for the Apollo Spacecraft	Oct. 16, 1964
SID-64-1867	Project Apollo End Item Specification Boilerplate No. 29	Nov. 20, 1964
SID-64-1137	Model Specification Mission Control Programmer Spacecraft 001	Dec. 4, 1964
SID-64-183	Vols. I & II - Apollo Technical Manuals Structural Loads and Criteria	Nov. 3, 1964
SID-64-1820	Vehicle Test Plan Apollo Mission A-002 (BP-23)	Oct. 20, 1964
SID-64-1707	Development Plan	Sept. 30, 1964
SID-64-1370	Performance and Interface Specification NASA-Furnished GSE Block II	Sept. 30, 1964
SID-64-62-702-1	Apollo Support Plan	Sept. 30, 1964
SID-64-1698	Apollo Manufacturing Plan	Oct. 15, 1964
SID-64-1847	Preliminary Weight and Balance Report for Airframe 009	Nov. 1, 1964
SID-64-1019	Project Apollo End Item Specification Spacecraft Lunar Excursion Module Adapter for Boilerplate 27	Oct. 27, 1964
SID-64-1371	Systems Trainers Specification Project Apollo Spacecraft	Oct. 14, 1964
SID-64-1819	Detailed Test Plan Spacecraft 009	Oct. 15, 1964
SID-64-1682	Interface Control Documentation Status Report	Oct. 10, 1964

Report number	Subject	Report date
SID-64T-163	Project Apollo End Item Specification for the Command Module Protective Cover, AFRM Model A14-180	Dec. 4, 1964

GRUMMAN AIRCRAFT CORPORATION
CONTRACT NAS 9-1100

Report number	Subject	Report date
LED-1200-8	Failure Effects Analysis-LEM Propellant Tank Assembly Ascent Stage	Nov. 30, 1964
LED-5051-4	Thermal Analysis - LEM Gimbal Drive Actuator Stabilization and Control	Dec. 7, 1964
LPR-1070-2	Status and Progress Report, LEM Actuation Subsystem	Dec. 9, 1964
LPR-550-113	Monthly Failure Summary Lunar Excursion Module	Oct. 15, 1964
LPL-825-1	LEM Spares Planning Document	Sept. 14, 1964
LED-400-34	LTA-1 Support Equipment	Oct. 9, 1964
LED-400-34	LTA-4 LTA-6 LTA-10 Support Equipment List	Oct. 9, 1964
LLI-400-7	Special Test Equipment Planning and Requirements List, Rev. B.	Sept. 15, 1964
LPR-50-23	Grumman Monthly Quality Status Report for Lunar Excursion Module	Dec. 10, 1964
LLI-400-1	Revision G, GSE Planning and Requirements List	Oct. 29, 1964
LED-3060-3	LEM System and Subsystem Failure Effects Analysis, Attitude Translation Control Assembly	Sept. 21, 1964
LPR-2000-59	Reliability Status Report LEM Ascent Engine	Oct. 7, 1964
LPR 3030-27	Monthly Progress Report - LEM System Engineering Tasks	Sept. 30, 1964

Report number	Subject	Report date
LPL-6071-1	LEM Descent Engine Control Assembly Program Plan	Oct. 9, 1964
LED-1450-4A	Configuration Analysis for Couplings, Manual Disconnect, Oxidizer and Fuel LEM Ascent and Descent Propulsion System	Oct. 23, 1964
LED-1480-6	Design Report LEM, Pulse Code Modulation and Timing Equipment	Oct. 16, 1964
LED-6070-11	Volumes I, II, III Second Quarterly Design Report LEM Communication Subsystem	Nov. 15, 1964
LED-2010-5	Failure Effect Analysis LEM Tanks Positive Expulsion Propellant	Nov. 20, 1964
LPC 6070-4A	LEM Configuration Control Procedure, Communications Subsystem	Nov. 15, 1964
LED-2800-9	Stress Analysis of LEM Descent Stage Tanks Preliminary Design Configuration	Oct. 28, 1964
LED-2000-55	Study Summary Report - LEM Ascent Engine	Oct. 31, 1964
LTR-1160-2	Final Test Report LEM, PC6A-1 Fuel Cell Assembly Experimental Model	Sept. 25, 1964
LED-490-15	LEM MASS Property Report	Dec. 1, 1964
LPR-50-22	Grumman Quarterly Summary of Quality Control Program Performance Audits for Lunar Excursion Module - Report no. 4	Nov. 10, 1964

GENERAL DYNAMICS/CONVAIR
CONTRACT NAS 9-492

D3026A01	Little Joe II Drawing List	Dec. 18, 1964
12-08901	Launch Vehicle Operations Manual	Nov. 13, 1964

Report number	Subject	Report date
12-09119	Ground Support Equipment Performance and Interface Specification for Ground Service Supply Hoses, Little Joe II, Revision C	Nov. 10, 1964
12-09298	Performance and Interface Specification, Little Joe II Standard GSE Portable Test Equipment	Dec. 14, 1964
GD/C 64-332	Test Report, Integrated Attitude Control System Tests	Nov. 30, 1964
533	Monthly Financial Management Report	Nov. 30, 1964
GD/C 62-157	Little Joe II Documentation Summary, Revision G	Nov. 30, 1964
GD/C 64-234	Qualification Status Summary, Little Joe II Vehicle 12-51-1	Nov. 27, 1964
GD/C 62-170	Hardware List, Little Joe II Test Launch Vehicle, Revision B	Dec. 11, 1964
CVR 48-02-67	Monthly Quality Report, Little Joe II Project	Nov. 30, 1964
GD/C 64-351	Monthly Progress Report No. 21	Dec. 10, 1964
GD/C 64-114	Checkout Manual, Launch Vehicle 12-51-1, Revision A, Vol I, II, and III	November 1964
12-9297	Ground Support Equipment Performance and Interface Specification for Platform, Range Safety System, Little Joe II	Oct. 27, 1964
12-09295	Ground Support Equipment Performance and Interface Specification for Rigging Fixture, BP-22 and AFR 02 Umbilical	Oct. 16, 1964
GD/C 64-304	Quarterly Reliability Status Report No. 10, NASA Project Apollo Little Joe II Test Launch Vehicle	Oct. 26, 1964

AiRESEARCH

Report number	Subject	Report date
SS-1013-R(28)	Monthly Progress Report, ECS, Program Apollo	Sept. 30, 1964
SS-1013-R(29)	Monthly Progress Report, ECS, Program Apollo	Oct. 31, 1964
SS-1013-R(30)	Monthly Progress Report, ECS, Program Apollo	Nov. 31, 1964

GENERAL DYNAMICS/CONVAIR
Contract NAS 9-492

GD/C 64-242	Narrative End Item Report	Dec. 1964
GD/C 12-08901	Launch Vehicle Operation Manual (12-51-1) Mission A-002	Nov. 13, 1964

Contract NAS 9-3716

-	Apollo Docking Test Device Design Study	Dec. 18, 1964

HAMILTON STANDARD
Contract NAS 9-1100

SVHSER 2790-14	LEM Environmental Control Sub-system Progress Report	Sept. 1954
SVHSER 2790-15	LEM Environmental Control Sub-system Progress Report	Oct. 1964
SVHSER 2807-5	LEM Environmental Control and Life Support Subsystem Quarterly Design Report	Sept. 30, 1964
SVHSER 2595F	Apollo Spacecraft Interface Specification	Nov. 20, 1964

Contract NAS 9-3535

Report number	Subject	Report date
PR-13-5-64	Progress Report on Extravehicular Mobility Unit	Sept. 1964
PR-14-6-64	Progress Report on Extravehicular Mobility Unit	Oct. 1964
PR-15-7-64	Progress Report on Extravehicular Mobility Unit	Nov. 1964

LOCKHEED PROPULSION COMPANY
Contract M3V3XA-406011

29	Monthly Progress Report for Apollo Launch Escape and Pitch Control Motors	Oct. 1964
30	Monthly Progress Report for Apollo Launch Escape and Pitch Control Motors	Nov. 1964
-	Qualification Test Report, Apollo Pitch Control Motor	Dec. 8, 1964
-	Qualification Test Report, Apollo Launch Escape Motor	Dec. 10, 1964

NORTHROP SPACE LABS
Contract NAS 9-3717

-	Apollo Docking Test Device Design Study	Dec. 1964

THIOKOL CHEMICAL CORPORATION
Contract M3VJXZ-406010

26	Apollo Tower Jettison Program Monthly Progress Report	Oct. 1964
27	Apollo Tower Jettison Program Monthly Progress Report	Nov. 1964

Report number	Subject	Report date
28	Apollo Tower Jettison Program Monthly Progress Report	Dec. 1964
	AC SPARK PLUG CONTRACT NAS 9-469	
533	Financial Management Report	Dec. 30, 1964
32	Monthly Report 25 IRIG Apollo I Program	Dec. 1964
	AC SPARK PLUG CONTRACT NAS 9-497	
533	Financial Management Report	Dec. 31, 1964
EP64-2J	Monthly Technical Progress Report	October 1964
EP64-21	Apollo G&N System Quarterly Technical Progress Report, September 1964	Oct. 15, 1964
EP64-3I	Quarterly Reliability Progress Report	September 1964
ND-1021036 Sup. Rev. A	Guidance and Navigation System Checkout Maintenance and Repair Manual	Apr. 23, 1964
AP-M-4823	Quarterly Summary of Quality Program Performance Audits for Period 1 through 30, September 1964	September 1964
AA-64-11	Structural Analysis of Optical Unit, Final Report	Nov. 15, 1964
	AC SPARK PLUG CONTRACT NAS 9-3426	
MPR4	Monthly Report for December – 25 IRIG Apollo II Program	December 1964
533	Financial Management Report	Dec. 30, 1964

Report number	Subject	Report date
#2	25 IRIG Apollo II Program Monthly Report for Oct. 1964	October 1964
	Configuration Management Procedure for 25 IRIG Apollo II	Sept. 1, 1964
1	Quarterly Progress Report	Nov. 30, 1964

IBM
CONTRACT NAS 9-3724

64-928-84	Monthly Progress Report on the Apollo Backup Computer Program	Sept. 21, 1964
64-928-89	Apollo Backup Computer Program	Dec. 15, 1964

AEROJET
CONTRACT NAS 9-2488

LJ-9	Acceptance Data Package	Dec. 10, 1964
LJ-8	Acceptance Data Package	Dec. 10, 1964

KOLLSMAN
CONTRACT NAS 9-2632

533	Financial Management Report	Sept. 30, 1964
9	Apollo Program Quarterly Technical Progress Report #9	Sept. 30, 1964
AA640105	Apollo Program Monthly Technical Progress Report #18	Aug. 31, 1964
533	Financial Management Report	Dec. 31, 1964
#4	LEM Program Monthly Technical Progress Report No. 4	Nov. 30, 1964

MIT
CONTRACT NAS 9-153

Report number	Subject	Report date
533	Financial Management Report	November 1964
E-1113	System Identification Data List	Nov. 17, 1964
E-1142 (Rev. 27)	System Status Report	Dec. 15, 1964
E-1551	Functions and Mechanization of Apollo Guidance and Navigation System - Volume I	August 1964
E-1679	Progress Report on Attainable Reliability of Integrated Circuits for System Application	November 1964
E-1713	Combustion of Polyolefin Insulation and Toxicity of Teflon Under Electrical Overloads	December 1964
R-349 (Rev. C)	G&N System Reliability Program	September 1964
R-456	E-Guidance-A General Explicit, Optimizing Law for Rocket Propelled Spacecraft	August 1964
R-457	Apollo G&N Quarterly Reliability and Quality Assurance Progress Period Ending June 30, 1964	June 1964
R-467	The Compleat Sunrise, Being A Description of Program Sunrise (Sunrise 33 NASA DWG#1021102)	September 1964
R-476	Reliability and Quality Assurance Progress Report	September 1964
T-385	Human Performance During a Simulated Apollo Mid-Course Navigation Sighting	June 1964

RAYTHEON
CONTRACT NAS 9-498

Report number	Subject	Report Date
ND1021001	Apollo Guidance and Navigation Checkout Maintenance and Repair Manual Vol I and Vol II	Oct. 20, 1964
ND1021005	Connections Manual Volumes I, II, and III	Dec. 1, 1964

SPERRY
CONTRACT NAS 9-455

533	Financial Management Report	December 1964
N0127	Apollo 15 PIP Model D Reliability and Qualifications Test Program Progress Report	Dec. 18, 1964

SPERRY
CONTRACT NAS 9-2847

11	Apollo 16 PIP Model D. Production Program Progress Report - Semi-monthly Edition	Dec. 15, 1964

GENERAL ELECTRIC
CONTRACT NASw-410

NAS-410-ACE-S/C-4MR10	ACE-S/C Monthly Progress Report	Dec. 1, 1964
NASw-410-AM-04	Operators Manual Acceptance Check-out Equipment Spacecraft	Dec. 15, 1964
NASw-410-AM-16	Vols. I, II, III ACE-S/C Maintenance Manual Acceptance Checkout Equipment Spacecraft, Ground Station No. 1 and No. 2	Nov. 16, 1964
NASw-410-30-13-40	ACE S/C Ground Station Training Plan	Sept. 16, 1964

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NASA

Report number	Subject	Report date
MSC-CSD-A054	Statement of Work - Program Apollo Block I Space Suit Assembly Development and Support Program	
Langley Research Center Report	Preliminary Flight Test Results of the Apollo Heat Shield Material at 28 000 Feet per Second	
MSC-CSD-A	Apollo Extravehicular Mobility Unit Design and Performance Specification	Dec. 28, 1964

UNCLASSIFIED

D035Z: 79N76512
D090A: 19790077004
D090F: 1979077004
D245A: Apollo spacecraft program Quarterly status report, period ending 31
Dec. 1964
D937A: CASI